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Upper Clark Fork River Tributaries Sediment, Metals, and Temperature TMDLs and Framework for Water Quality Restoration

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ERRATA SHEET FOR THE UPPER CLARK FORK RIVER TRIBUTARIES SEDIMENT, METALS AND TEMPERATURE TMDLS AND FRAMEWORK FOR WATER QUALITY RESTORATION

This TMDL was approved by EPA on March 4, 2010. Several copies were printed and spiral bound for distribution, or sent electronically on compact disks. The original version had a minor change that is explained and corrected on this errata sheet. If you have a bound copy, please note the correction listed below or simply print out the errata sheet and insert it in your copy of the TMDL. If you have a compact disk please add this errata sheet to your disk or download the updated version from our website.

The appropriate correction has already been made in the downloadable version of the TMDL located on our website at: http://deq.mt.gov/wqinfo/TMDL/finalReports.mcpx

The following table contains the correction to the TMDL. The first column cites the page and paragraph where there is a text error. The second column contains the original text that was in error. The third column contains the new text that has been corrected for the Upper Clark Fork River Tributaries Sediment, Metals and Temperature TMDLs and Framework for Water Quality Restoration document. The text in error and the correct text are underlined.

Location in the TMDL	**Original Text**	**Corrected Text**
Page 88, Section 5.6.10, under Storm Water Discharge Permit, Second paragraph, 5th Sentence	If we were to theorize a worst-case scenario using the condition of the target concentration (100mg/l), the maximum allowable annual sediment load from this site would equate to approximately 4.9 tons/year.	If we were to theorize a worst-case scenario using the condition of the target concentration (100mg/l), the maximum allowable annual sediment load from this site would equate to approximately 0.49 tons/year.

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ACRONYM LIST

AFFCO	Anaconda Foundry and Fabrication Company
ARAR	Applicable or Relevant and Appropriate Requirements
ARM	Administrative Rules of Montana
BDNF	Beaverhead-Deerlodge National Forest
BER	Board of Environmental Review, Montana
BLM	Bureau of Land Management, United States
BMP	Best Management Practice
BNSF	Burlington Northern Santa Fe
CAFO	Confined Animal Feeding Operation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	Cubic Feet per Second
CN	Curve Number
COC	Constituents of Concern
CWA	Clean Water Act
DEQ	Department of Environmental Quality, Montana
EMAP	Environmental Monitoring and Assessment Program
FWP	Fish, Wildlife, and Parks, Montana Department of
GIS	Geographic Information System
GWIC	Groundwater Information Center, MBMG
HUC	Hydrologic Unit Code
in	inches
ITL	Instantaneous Thermal Load
LA	Load Allocation
lbs/day	pounds per day
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
mg/L	Milligrams Per Liter
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
NPL	National Priority List
NRCS	National Resource Conservation Service
PEL	Probable Effect Level
PFC	Proper Functioning Condition
RI	Remedial Investigations
ROD	Record of Decision
SCD/BUD	Sufficient Credible Data / Beneficial Use Determination
STATSGO	State Soil Geographic [database]
SWMP	Stormwater Management Plan
SWPPP	Stormwater Pollution Prevention Plan
TI	Technical Impractability
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area
TR	Total Recoverable

TSS	Total Suspended Solids
UAA	Use Attainability Analysis
µg/g	microgram per gram
ug/L	microgram per liter
UILT	Upper Incipient Lethal Temperature
U.S. EPA	United States Environmental Protection Agency
USFS	United States National Forest Service
USGS	United States Geologic Survey
USLE	Universal Soil Loss Equation
WLA	Waste Load Allocation

EXECUTIVE SUMMARY

This document presents a Total Maximum Daily Load (TMDL) and framework water quality restoration for 78 pollutant-water body combinations on nineteen impaired tributaries in the Upper Clark Fork River TMDL Planning Area (TPA). The Upper Clark Fork TPA extends from Butte to Drummond, Montana, and includes Antelope, Beefstraight, Brock, Cable, Dempsey, Dunkleberg, Gold, Hoover, Lost, Mill, Modesty, Peterson, Tin Cup Joe, Warm Springs (near Anaconda), Warm Springs (near Phosphate) Willow, and Storm Lake creeks, and German Gulch and Mill-Willow Bypass (the Clark Fork River, Silver Bow Creek, and the Little Blackfoot River and its tributaries are addressed as a separate TPA and will be focused on in future TMDLs). This plan was developed by the Montana Department of Environmental Quality (DEQ) and submitted to the U.S. Environmental Protection Agency (U.S. EPA) for approval. The Montana Water Quality Act requires DEQ to develop TMDLs for streams and lakes that do not meet, or are not expected to meet, Montana water quality standards. A TMDL is the maximum amount of a pollutant a water body can receive and still meet water quality standards. The goal of TMDLs is to eventually attain and maintain water quality standards in all of Montana's streams and lakes, and to improve water quality to levels that support all state-designated beneficial water uses.

The Upper Clark Fork TMDL Planning Area is located in Granite, Silverbow, and Deer Lodge counties and includes the Clark Fork River and its tributaries from Butte to the Flint Creek confluence near Drummond. The TPA is bounded by the Boulder Mountains to the east, the Highland and Anaconda Ranges to the south, the Flint Creek Range to the west, and the Garnet Range to the north. The total area is 955,622 acres, or approximately 1,493 square miles, with land ownership consisting of federal, state, and private lands.

DEQ has performed assessments determining that the above listed tributaries, or segments of these tributaries, do not meet the applicable water quality standards. The scope of the TMDLs in this document address sediment, metals, and temperature related problems for Clark Fork tributaries (See **Table ES-1**). The DEQ recognizes there are other pollutant listings for this TPA, and sediment, metals, and temperature TMDLs for the mainstem Clark Fork River and Silver Bow Creek, as well as nutrient TMDLs for the TPA as a whole will be developed in a future document.

Sediment

Sediment was identified as a cause of impairment of aquatic life, coldwater fisheries, and/or public contact recreation in Antelope, Brock, Cable, Dempsey, Hoover, Peterson, Tin Cup Joe, Warm Springs (near Phosphate), Willow and Storm Lake creeks. Sediment is impacting beneficial water uses in these streams by altering aquatic insect communities, reducing fish spawning success, and increasing levels of turbidity. Water quality restoration goals for sediment in these stream segments were established on the basis of stream morphology, fine sediment levels in trout spawning areas, pool quality and riparian condition. DEQ believes that once these water quality goals are met, beneficial uses currently impacted by sediment will be restored.

Sediment loads were quantified for natural background conditions and for the following sources: bank erosion, upland/hillslope erosion, and sediment from road crossings. The Upper Clark Fork tributaries sediment TMDLs indicate that reductions in sediment loads ranging from 26% to 54% will result in meeting the water quality restoration goals.

Metals

Metals related impacts were identified as a cause of impairment to the beneficial uses of agriculture, aquatic life, coldwater fish, and drinking water in Beefstraight, Dunkleberg, Gold, Lost, Mill, Modesty, Peterson, Warm Springs (near Anaconda), and Willow creeks, and in German Gulch and Mill-Willow Bypass. Identified metals affecting some or all of these streams are Arsenic, Cadmium, Copper, Cyanide, Iron, Lead, Selenium, and Zinc. Water quality goals for metals are based on Montana's numeric water quality standards for these metals.

Metals loads were determined by the collection and review of water chemistry data throughout each of the listed watersheds. Sampling locations were chosen to observe the temporal metals loading fluctuations (high flow, low flow, and storm events) and to identify source areas or discrete sources and include tributary drainages, abandoned mines, and historic atmospheric deposition. Metal load reductions necessary to meet TMDL based on the known data range from 8% to 96% depending on the stream and pollutant combination.

Temperature

Temperature related impacts were identified as a cause of impairment to the beneficial uses of aquatic life and coldwater fisheries in Peterson Creek. Water quality restoration goals to meet the temperature standard for Peterson Creek include improving riparian shade, maintaining current stream dimensions, improving irrigation infrastructure, and reducing human caused surface water inflow. DEQ believes that once these water quality goals are met, all water uses currently impacted by temperature will be restored.

Temperature loads were quantified using a QUAL2K water quality model which investigated various scenarios to identify the current condition of Peterson Creek, and the potential improvement in temperature under certain circumstances. The model showed temperature reductions capable of as much as 13 degrees in some sections of the stream under certain situations.

Recommended strategies for achieving the pollutant reduction goals of the Upper Clark Fork Tributaries TMDLs are also presented in this plan. They include best management practices (BMPs) for agriculture, timber harvest, roads, and mining lands, as well as expanding riparian buffer areas and using other land, soil, and water conservation practices that improve the condition of stream channels and associated riparian vegetation.

Implementation of most water quality improvement measures described in this plan is based on voluntary actions of watershed stakeholders. Ideally, the TMDL and associated information within this document will be used by a local watershed group and/or other watershed stakeholders as a tool to help guide and prioritize local water quality improvement activities. These improvement activities can be documented within a watershed restoration plan consistent with DEQ and EPA recommendations.

It is recognized that a flexible and adaptive approach to most TMDL implementation activities may become necessary as more knowledge is gained through implementation and future monitoring. The plan includes an effectiveness monitoring strategy that is designed to track future progress towards meeting TMDL objectives and goals, and to help refine the plan during its implementation.

Table ES-1. Impaired Water Bodies, Impairment Causes, and Impaired Beneficial Uses in the Upper Clark Fork TPA for Which TMDLs Were Completed.

Water body & Location Description	Water body ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Antelope Creek, headwaters to mouth (Gardner Gulch)	MT76G003_031	**Sedimentation/ Siltation**	**Sediment**	Primary Contact Recreation*
Beefstraight Creek, Minnesota Gulch to mouth (German Gulch)	MT76G003_031	**Cyanide**	**Metals**	Aquatic Life, Cold Water Fishery*
Brock Creek, headwaters to mouth (Clark Fork River)	MT76G005_100	**Sedimentation/ Siltation**	**Sediment**	Primary Contact Recreation*
Cable Creek, the headwaters to the mouth (Warm Springs Creek)	MT76G002_030	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
Dempsey Creek, the national forest boundary to the mouth (Clark Fork River)	MT76G002_100	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
Dunkleberg Creek, headwaters SW corner Sec 2, T9N, R12W	MT76G005_071	**Arsenic**	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Cadmium	**Metals**	Aquatic Life, Cold Water Fishery
		Copper	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery
		Iron	**Metals**	Aquatic Life, Cold Water Fishery
		Zinc	**Metals**	Aquatic Life, Cold Water Fishery
Dunkleberg Creek, SW corner Sec 2, T9N, R12W to mouth (Clark Fork River)	MT76G005_072	**Arsenic**	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Cadmium	**Metals**	Aquatic Life, Cold Water Fishery
		Copper	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery
		Iron	**Metals**	Aquatic Life, Cold Water Fishery
		Zinc	**Metals**	Aquatic Life, Cold Water Fishery

Table ES-1. Impaired Water Bodies, Impairment Causes, and Impaired Beneficial Uses in the Upper Clark Fork TPA for Which TMDLs Were Completed.

Water body & Location Description	Water body ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
German Gulch, headwaters to mouth (Silver Bow Creek)	MT76G003_030	**Arsenic**	**Metals**	Aquatic Life, Cold Water Fishery
		Cyanide	**Metals**	Aquatic Life, Cold Water Fishery
		Selenium	**Metals**	Aquatic Life, Cold Water Fishery
Gold Creek, headwaters to the Natl. Forest boundary	MT76G005_091	**Lead**	**Metals**	Aquatic Life, Cold Water Fishery
Gold Creek, the forest boundary to the mouth (Clark Fork River)	MT76G005_092	**Iron**	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery
Hoover Creek, headwaters to Miller Lake	MT76G005_081	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
Hoover Creek, Miller Lake to mouth (Clark Fork)	MT76G005_082	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
Lost Creek, the south State Park boundary to the mouth (Clark Fork River)	MT76G002_072	**Arsenic**	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Copper	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery
Mill Creek, headwaters to the section line between Sec 27 & 28, T4N, R11W	MT76G002_051	**Arsenic**	**Metals**	Aquatic Life, Cold Water Fishery
		Cadmium	**Metals**	Aquatic Life, Cold Water Fishery
		Copper	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery
		Zinc	**Metals**	Aquatic Life, Cold Water Fishery

Table ES-1. Impaired Water Bodies, Impairment Causes, and Impaired Beneficial Uses in the Upper Clark Fork TPA for Which TMDLs Were Completed.

Water body & Location Description	Water body ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Mill Creek, section line between Sec 27 & 28, T4N, R11W to the mouth (Silver Bow Creek)	MT76G002_052	**Arsenic**	**Metals**	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water
		Cadmium	**Metals**	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water
		Copper	**Metals**	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water
		Lead	**Metals**	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water
		Iron	**Metals**	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water
		Zinc	**Metals**	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water
Mill-Willow Bypass, from Silver Bow Creek to the Clark Fork River	MT76G002_120	**Arsenic**	**Metals**	Drinking Water
		Cadmium	**Metals**	Aquatic Life, Cold Water Fishery
		Copper	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Zinc	**Metals**	Aquatic Life, Cold Water Fishery
Modesty Creek, headwaters to the mouth (Clark Fork River)	MT76G002_080	**Arsenic**	**Metals**	Drinking Water
		Cadmium	**Metals**	Aquatic Life, Cold Water Fishery
		Copper	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery

Table ES-1. Impaired Water Bodies, Impairment Causes, and Impaired Beneficial Uses in the Upper Clark Fork TPA for Which TMDLs Were Completed.

Water body & Location Description	Water body ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Peterson Creek, headwaters to Jack Creek	MT76G002_131	**Copper**	**Metals**	Aquatic Life, Cold Water Fishery
		Iron	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery
		Sedimentation/ Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
Peterson Creek, Jack Creek to the mouth (Clark Fork River)	MT76G002_132	**Temperature (water)**	**Temperature**	Aquatic Life, Cold Water Fishery*
		Sedimentation/ Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
		Iron	**Metals**	Aquatic Life, Cold Water Fishery
Storm Lake Creek, headwaters to mouth (Warm Springs Creek)	MT76G002_040	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
Tin Cup Joe Creek, Tin Cup Lake to mouth (Clark Fork River)	MT76G002_110	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
Warm Springs Creek, (Near Phosphate) from line between R9W and R10W to mouth (Clark Fork River)	MT76G005_112	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
Warm Springs Creek, (near Warm Springs), Meyers Dam (T5N, R12W, SEC 25) to mouth (Clark Fork)	MT76G002_012	**Arsenic**	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Cadmium	**Metals**	Aquatic Life, Cold Water Fishery
		Copper	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery
		Iron	**Metals**	Aquatic Life, Cold Water Fishery
		Zinc	**Metals**	Aquatic Life, Cold Water Fishery

Table ES-1. Impaired Water Bodies, Impairment Causes, and Impaired Beneficial Uses in the Upper Clark Fork TPA for Which TMDLs Were Completed.

Water body & Location Description	Water body ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Willow Creek, headwaters to T4N, R10W, Sec30 (DABC)	MT76G002_061	**Arsenic**	**Metals**	Drinking Water, Primary Contact Recreation
		Cadmium	**Metals**	Aquatic Life, Cold Water Fishery
		Copper	**Metals**	Aquatic Life, Cold Water Fishery
		Iron	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery
		Zinc	**Metals**	Aquatic Life, Cold Water Fishery
		Sedimentation/ Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
Willow Creek, T4N, R10W, Sec30 (DABC) to mouth (Silver Bow Creek)	MT76G002_062	**Arsenic**	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Cadmium	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Copper	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Iron	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Lead	**Metals**	Aquatic Life, Cold Water Fishery
		Zinc	**Metals**	Aquatic Life, Cold Water Fishery
		Sedimentation/ Siltation	**Sediment**	Aquatic Life, Cold Water Fishery

SECTION 1.0
INTRODUCTION

1.1 Background

This document, *The Upper Clark Fork Tributaries TMDLs and Framework Watershed Water Quality Improvement Plan*, describes the Montana Department of Environmental Quality's current understanding of sediment, metals, and temperature related water quality problems in rivers and streams of the Upper Clark Fork TMDL Planning Area (TPA) and presents a general framework for resolving them. The Upper Clark Fork TPA encompasses the Clark Fork watershed from its headwaters near Butte to the confluence with Flint Creek near Drummond, however this document focuses only on sediment, metals, and temperature TMDLs for Clark Fork tributaries, and excludes the Clark Fork River and Silver Bow Creek. **Figures A-1** and **A-2a-2c** found in **Appendix A** shows a map of water bodies in the TPA with sediment, metals, and temperature pollutant listings addressed in this document. Pollutants affecting Clark Fork River and Silver Bow Creek, and nutrients in Upper Clark Fork tributaries will be addressed in a future document.

Congress passed the Water Pollution Control Act, more commonly known as the Clean Water Act, in 1972. The goal of this act is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The Clean Water Act requires each state to set water quality standards to protect designated beneficial water uses and to monitor the attainment of those uses. Fish and aquatic life, wildlife, recreation, agriculture, industrial, and drinking water are all types of beneficial uses designated in Montana. Streams and lakes (also referred to as water bodies) not meeting the established standards are called *impaired waters*, and those not expected to meet the standards are called *threatened waters*.

The water bodies with their associated impairment and threatened causes are identified within a biennial integrated water quality report developed by DEQ. Impairment causes fall within two main categories: pollutant and pollution. Both Montana state law (Section 75-5-701 of the Montana Water Quality Act) and section 303(d) of the federal Clean Water Act require the development of total maximum daily loads (TMDLs) for impaired and threatened waters where a measurable pollutant (for example, sediment, nutrients, metals or temperature) is the cause of the impairment. The water body segments with pollutant impairment causes in need of TMDL development are contained within the 303(d) List portion of the State's integrated water quality report. The integrated report identifies impaired waters by a Montana water body segment identification, which is indexed to the National Hydrography Dataset. **Table 1-1** identifies the water bodies identified as impaired or threatened by pollutants and pollution in the Upper Clark Fork TPA (Silver Bow Creek and Clark Fork River excluded).

Table 1-1. 2008 Impaired Water Bodies, Impairment Causes, and Impaired Beneficial Uses in the Upper Clark Fork TPA.

Water body & Location Description	Water body ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Antelope Creek, headwaters to mouth (Gardner Gulch)	MT76G003_031	Low Flow Alterations	*Not a Pollutant*	Primary Contact Recreation*
Beefstraight Creek, Minnesota Gulch to mouth (German Gulch)	MT76G003_031	**Cyanide**	**Metals**	Aquatic Life, Cold Water Fishery*
Brock Creek, headwaters to mouth (Clark Fork River)	MT76G005_100	**Sedimentation/ Siltation**	**Sediment**	Primary Contact Recreation*
Cable Creek, the headwaters to the mouth (Warm Springs Creek)	MT76G002_030	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
		Other Anthropogenic substrate alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
		Physical substrate habitat alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
		Chlorophyll a	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
Dempsey Creek, the national forest boundary to the mouth (Clark Fork River)	MT76G002_100	Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Aquatic Life, Cold Water Fishery
		Sedimentation/ Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
		Low Flow Alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
Dunkleberg Creek, headwaters SW corner Sec 2, T9N, R12W	MT76G005_071	**Cadmium**	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Zinc	**Metals**	Aquatic Life, Cold Water Fishery
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
Dunkleberg Creek, SW corner Sec 2, T9N, R12W to mouth (Clark Fork River)	MT76G005_072	**Lead**	**Metals**	Aquatic Life, Cold Water Fishery
		Nitrogen (Total)	Nutrients	Aquatic Life, Cold Water Fishery
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery

Table 1-1. 2008 Impaired Water Bodies, Impairment Causes, and Impaired Beneficial Uses in the Upper Clark Fork TPA.

Water body & Location Description	Water body ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
German Gulch, headwaters to mouth (Silver Bow Creek)	MT76G003_030	**Selenium**	**Metals**	Aquatic Life, Cold Water Fishery
Gold Creek, headwaters to the Natl. Forest boundary	MT76G005_091	**Lead**	**Metals**	Aquatic Life, Cold Water Fishery
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Drinking Water
Gold Creek, the forest boundary to the mouth (Clark Fork River)	MT76G005_092	Nitrogen (Total)	Nutrients	Aquatic Life, Cold Water Fishery
		Low Flow Alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
Hoover Creek, headwaters to Miller Lake	MT76G005_081	**Turbidity**	**Sediment**	Primary Contact Recreation*
		Sedimentation/ Siltation	**Sediment**	Primary Contact Recreation*
Hoover Creek, Miller Lake to mouth (Clark Fork)	MT76G005_082	Nitrogen (Total)	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation*
		Low Flow Alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation*
		Physical substrate habitat alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation*
Lost Creek, the south State Park boundary to the mouth (Clark Fork River)	MT76G002_072	**Arsenic**	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Iron	**Metals**	Aquatic Life, Cold Water Fishery
		Manganese	**Metals**	Aquatic Life, Cold Water Fishery
		Sulfates	**Metals**	Aquatic Life, Cold Water Fishery
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Aquatic Life, Cold Water Fishery
		Low Flow Alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
		Physical substrate habitat alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery

Table 1-1. 2008 Impaired Water Bodies, Impairment Causes, and Impaired Beneficial Uses in the Upper Clark Fork TPA.

Water body & Location Description	Water body ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Mill Creek, headwaters to the section line between Sec 27 & 28, T4N, R11W	MT76G002_051	**Arsenic**	**Metals**	Aquatic Life, Cold Water Fishery
		Cadmium	**Metals**	Aquatic Life, Cold Water Fishery
		Chromium (Total)	**Metals**	Aquatic Life, Cold Water Fishery
		Copper	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery
		Zinc	**Metals**	Aquatic Life, Cold Water Fishery
Mill Creek, section line between Sec 27 & 28, T4N, R11W to the mouth (Silver Bow Creek)	MT76G002_052	**Aluminum**	**Metals**	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water
		Arsenic	**Metals**	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water
		Cadmium	**Metals**	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water
		Copper	**Metals**	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water
		Lead	**Metals**	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water
		Iron	**Metals**	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water
		Zinc	**Metals**	Agricultural, Aquatic Life, Cold Water Fishery, Drinking Water
		Low Flow Alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
Mill-Willow Bypass, from Silver Bow Creek to the Clark Fork River	MT76G002_120	**Arsenic**	**Metals**	Drinking Water
		Copper	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
Modesty Creek, headwaters to the mouth (Clark Fork River)	MT76G002_080	**Arsenic**	**Metals**	Drinking Water*
		Low Flow Alterations	*Not a Pollutant*	Primary Contact Recreation*

Table 1-1. 2008 Impaired Water Bodies, Impairment Causes, and Impaired Beneficial Uses in the Upper Clark Fork TPA.

Water body & Location Description	Water body ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Peterson Creek, headwaters to Jack Creek	MT76G002_131	**Copper**	**Metals**	Aquatic Life, Cold Water Fishery
		Nitrogen (Total)	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Phosphorus (Total	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Total Kjehldahl Nitrogen (TKN)	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Sedimentation/ Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
		Low Flow Alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
Peterson Creek, Jack Creek to the mouth (Clark Fork River)	MT76G002_132	**Temperature (water)**	**Temperature**	Aquatic Life, Cold Water Fishery*
		Low Flow Alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery*
		Physical substrate habitat alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery*
Racetrack Creek, the national forest boundary to the mouth (Clark Fork River)	MT76G002_090	Low Flow Alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
Storm Lake Creek, headwaters to mouth (Warm Springs Creek)	MT76G002_040	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
		Low Flow Alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
		Chlorophyll a	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
Tin Cup Joe Creek, Tin Cup Lake to mouth (Clark Fork River)	MT76G002_110	Low Flow Alterations	*Not a Pollutant*	Agriculture

Table 1-1. 2008 Impaired Water Bodies, Impairment Causes, and Impaired Beneficial Uses in the Upper Clark Fork TPA.

Water body & Location Description	Water body ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Warm Springs Creek, (Near Phosphate), headwaters to the line between R9W and R10W	MT76G005_111	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
Warm Springs Creek, (Near Phosphate) from line between R9W and R10W to mouth (Clark Fork River)	MT76G005_112	**Sedimentation/ Siltation**	**Sediment**	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Low Flow Alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
		Physical substrate habitat alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
Warm Springs Creek, (near Warm Springs), headwaters to Meyers Dam (T5N, R12W, SEC 25)	MT76G002_011	Physical substrate habitat alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery*
Warm Springs Creek, (near Warm Springs), Meyers Dam (T5N, R12W, SEC 25) to mouth (Clark Fork)	MT76G002_012	**Arsenic**	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Copper	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery
		Low Flow Alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
		Physical substrate habitat alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery

Table 1-1. 2008 Impaired Water Bodies, Impairment Causes, and Impaired Beneficial Uses in the Upper Clark Fork TPA.

Water body & Location Description	Water body ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Willow Creek, headwaters to T4N, R10W, Sec30 (DABC)	MT76G002_061	**Arsenic**	**Metals**	Drinking Water, Primary Contact Recreation
		Cadmium	**Metals**	Aquatic Life, Cold Water Fishery
		Copper	**Metals**	Aquatic Life, Cold Water Fishery
		Lead	**Metals**	Aquatic Life, Cold Water Fishery
		Phosphorus (Total)	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Sedimentation/ Siltation	**Sediment**	Aquatic Life, Cold Water Fishery
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
Willow Creek, T4N, R10W, Sec30 (DABC) to mouth (Silver Bow Creek)	MT76G002_062	**Arsenic**	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Cadmium	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Copper	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Lead	**Metals**	Aquatic Life, Cold Water Fishery, Drinking Water
		Low Flow Alterations	*Not a Pollutant*	Aquatic Life, Cold Water Fishery
		Alteration in stream-side or littoral vegetative cover	*Not a Pollutant*	Aquatic Life, Cold Water Fishery

This document addresses those pollutant-water body combinations identified by bold text.
* Not all beneficial uses have been assessed.

A TMDL refers to the maximum amount of a pollutant a stream or lake can receive and still meet water quality standards. The development of TMDLs and water quality improvement strategies in Montana includes several steps that must be completed for each impaired or threatened water body and for each contributing pollutant (or “pollutant/water body combination”). These steps include:

1. Characterizing the existing water body conditions and comparing these conditions to water quality standards. During this step, measurable target values are set to help evaluate the stream’s condition in relation to the applicable standards.
2. Quantifying the magnitude of pollutant contribution from the pollutant sources.
3. Determining the TMDL for each pollutant, based on the allowable loading limits (or loading capacity) for each pollutant/water body combination.
4. Allocating the total allowable load (TMDL) into individual loads for each source (referred to as the load allocations or waste load allocations).

In Montana, restoration strategies and recommendations are also incorporated in TMDL documents to help facilitate TMDL implementation.

The above four TMDL steps are further defined in **Section 4.0** of this document. Basically, TMDL development for an impaired water body is a problem solving exercise. The problem is excess pollutant loading negatively impacting a designated beneficial use. The solution is developed by identifying the total acceptable pollutant load to the water body (the TMDL), characterizing all the significant sources contributing to the total pollutant loading, and then identifying where pollutant loading reductions should be applied to one or more sources to achieve the acceptable load.

1.2 Water Quality Impairments and TMDLs Addressed By This Plan

As shown by **Table 1-1**, there are several types of impairment causes which fall into different TMDL pollutant categories in the Upper Clark Fork TPA. For each impairment cause, the impaired beneficial uses are also identified and in the Upper Clark Fork include agriculture, aquatic life and cold water fisheries, drinking water, and primary contact recreation. Because TMDLs are completed for each pollutant/water body combination, this framework water quality improvement plan contains several TMDLs which address the pollutant impairment causes identified by bold text in **Table 1-1**. These pollutant impairment causes fall within the categories of sediment, metals, and temperature. TMDL development for each pollutant category will follow a similar process as reflected by the organization of this document and discussed further in **Section 1.3** below.

In addition to those pollutant-water body combinations identified in **Table 1-1**, data reviewed during this project justified the further development of sediment and metals TMDLs for a number of water bodies. Additional TMDLs developed in this document are identified in **Table 1-2**.

Table 1-2. Additional TMDLs developed in the Upper Clark Fork TPA.

Water body & Location Description	Water body ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Antelope Creek, headwaters to mouth (Gardner Gulch)	MT76G003_031	**Siltation / Sedimentation**	**Sediment**	Aquatic Life, Cold Water Fishery
Dunkleberg Creek, headwaters SW corner Sec 2, T9N, R12W	MT76G005_071	**Arsenic** **Copper** **Iron**	**Metals**	Aquatic Life, Cold Water Fishery
Dunkleberg Creek, SW corner Sec 2, T9N, R12W to mouth (Clark Fork River)	MT76G005_072	**Arsenic** **Cadmium** **Copper** **Iron** **Zinc**	**Metals**	Aquatic Life, Cold Water Fishery
German Gulch, headwaters to mouth (Silver Bow Creek)	MT76G003_030	**Arsenic** **Cyanide**	**Metals**	Aquatic Life, Cold Water Fishery

Table 1-2. Additional TMDLs developed in the Upper Clark Fork TPA.

Water body & Location Description	Water body ID	Impairment Cause	TMDL Pollutant Category	Impaired Uses
Gold Creek, the forest boundary to the mouth (Clark Fork River)	MT76G005_092	**Iron**	**Metals**	Aquatic Life, Cold Water Fishery
		Lead		
Hoover Creek, Miller Lake to mouth (Clark Fork)	MT76G005_082	**Siltation / Sedimentation**	**Sediment**	Aquatic Life, Cold Water Fishery
Lost Creek, the south State Park boundary to the mouth (Clark Fork River)	MT76G002_072	**Copper**	**Metals**	Aquatic Life, Cold Water Fishery
		Lead		
Mill-Willow Bypass, from Silver Bow Creek to the Clark Fork River	MT76G002_120	**Cadmium**	**Metals**	Aquatic Life, Cold Water Fishery
		Zinc		
Modesty Creek, headwaters to the mouth (Clark Fork River)	MT76G002_080	**Cadmium**	**Metals**	Aquatic Life, Cold Water Fishery
		Copper		
		Lead		
Peterson Creek, headwaters to Jack Creek	MT76G002_131	**Lead**	**Metals**	Aquatic Life, Cold Water Fishery
		Iron		
Peterson Creek, Jack Creek to the mouth (Clark Fork River)	MT76G002_132	**Siltation / Sedimentation**	**Sediment**	Aquatic Life, Cold Water Fishery
		Iron	**Metals**	
Tin Cup Joe Creek, Tin Cup Lake to mouth (Clark Fork River)	MT76G002_110	**Siltation / Sedimentation**	**Sediment**	Aquatic Life, Cold Water Fishery
Warm Springs Creek, (near Warm Springs), Meyers Dam (T5N, R12W, SEC 25) to mouth (Clark Fork)	MT76G002_012	**Cadmium**	**Metals**	Aquatic Life, Cold Water Fishery
		Iron		
		Zinc		
Willow Creek, headwaters to T4N, R10W, Sec30 (DABC)	MT76G002_061	**Iron**	**Metals**	Aquatic Life, Cold Water Fishery
		Zinc		
Willow Creek, T4N, R10W, Sec30 (DABC) to mouth (Silver Bow Creek)	MT76G002_062	**Iron**	**Metals**	Aquatic Life, Cold Water Fishery
		Zinc		
		Siltation / Sedimentation	**Sediment**	

Review of available data also has led to the determination that a sediment TMDL will not be pursued for upper Warm Springs Creek, near Phosphate (MT76G005_111). Review of available data for metals has concluded that a TMDL will not be pursued for the following water body/metals combinations: lower Lost Creek (MT76G002_072)/Iron, Manganese, Sulfates; upper Mill Creek (MT76G002_051)/Chromium (Total); lower Mill Creek (MT76G002_052)/Aluminum. The Turbidity pollutant listing for upper Hoover Creek is addressed through the Sediment TMDL and does not have a specific "turbidity TMDL". Details and rationale behind these conclusions can be found in the comparison to targets sections in **Sections 5** and **6** of this document.

This document addresses 13 sediment TMDLs, 64 metals TMDLs, and 1 temperature TMDL for a total of 78 TMDLs in the Upper Clark Fork TPA.

1.3 Document Layout

The main body of the document provides a summary of the TMDL components. Additional technical details of these components are contained in the appendices of this report. In addition to this introductory section which includes the brief TMDL background and identification of TMDLs developed, this document has been organized into the following sections:

Section 2.0 Upper Clark Fork Watershed Description:
Description of the physical and social characteristics of the watershed

Section 3.0 Montana Water Quality Standards:
Discusses the water quality standards that apply to the Upper Clark Fork watershed

Section 4.0 Description of TMDL Components:
Defines the components of a TMDL and the process by which they are developed.

Sections 5.0 – 7.0 Sediment, Metals, and Temperature TMDL Components, sequentially:
Discusses the pollutant category's impact to beneficial uses, the existing water quality conditions and the developed water quality targets, the quantified pollutant contributions from the identified sources, the determined TMDL, and the allocations.

Section 8.0 Other Problems/Concerns:
Describes other problems or issues that may potentially be contributing to water quality impairment and how the TMDLs in the plan may address some of these concerns. This section also provides recommendations for addressing these problems.

Section 9.0 Restoration Objectives and Implementation Plan:
Discusses water quality restoration objectives and presents a framework implementation strategy for meeting the identified objectives and TMDLs.

Section 10.0 Monitoring for Strategy and Adaptive Management:
Describes a water quality monitoring plan for evaluating the long term effectiveness of the Upper Clark Fork TMDLs and Framework Watershed Water Quality Improvement Plan.

Section 11.0 Public Participation & Public Comments:
Describes the involvement of other agencies and stakeholder groups who were involved with the development of the plan, the public participation process used in review of the draft document, and addresses comments received during the public review period.

SECTION 2.0
UPPER CLARK FORK WATERSHED DESCRIPTION

This report describes the physical, biological, and anthropogenic characteristics of the Upper Clark Fork of the Columbia River (**Figure A-1**), referred to as the Clark Fork River. The characterization establishes a context for impaired waters, as background for total maximum daily load (TMDL) planning. The Upper Clark Fork TMDL planning area differs from the Upper Clark Fork River 4th-order hydrologic unit code (HUC) in that it does not include the Little Blackfoot River watershed.

The Montana Department of Environmental Quality (DEQ) has identified 19 impaired water bodies within the Upper Clark Fork River watershed: the Clark Fork River, Beefstraight Creek, Brock Creek, Cable Creek, Dempsey Creek, Dunkleberg Creek, German Gulch, Gold Creek, Hoover Creek, Lost Creek, Mill Creek, Mill-Willow Bypass, Modesty Creek, Peterson Creek, Silver Bow Creek, Storm Lake Creek, Warm Springs Creek (near Warm Springs), Warm Springs Creek (near Phosphate), and Willow Creek. As discussed in **Section 1**, the Clark Fork River and Silver Bow Creek are not addressed within this document. Therefore, descriptive characteristics specific to the Clark Fork River and Silver Bow Creek are not included within the Watershed Description. The impairment listings are detailed in DEQ's Integrated 305(b)/303(d) Water Quality Report (DEQ, 2006), and are shown on **Figures A-2a-2c**. Impairment listings are summarized in **Section 1**.

2.1 Physical Characteristics

2.1.1 Location

The Upper Clark Fork TMDL planning area (TPA) is located in the Columbia River Basin (Accounting Unit 170102) of western Montana, as shown on **Figure A-1**. The TPA is located within the Middle Rockies Level III Ecoregion. Four Level IV Ecoregions are mapped within the TPA (**Figure A-3**). These include: Upper Clark Fork – Anaconda Mountains (17am), Alpine (17h), Deer Lodge – Philipsburg – Avon Grassy Intermontane Hills and Valleys (17ak) and Rattlesnake – Blackfoot – South Swan – Northern Garnet – Sapphire Mountains (17x) (Woods et al., 2002). The majority of the TPA is within Powell County, with small areas in Granite, Deer Lodge, and Silver Bow counties.

The TPA is bounded by the Boulder Mountains to the east, the Highland and Anaconda Ranges to the south, the Flint Creek Range to the west, and the Garnet Range to the north. The total area is 955,622 acres, or approximately 1,493 square miles.

2.1.2 Topography

Elevations in the TPA range from approximately 1,200 to 3,230 meters (3,900 - 10,600 feet) above mean sea level (**Figure A-4**). The mean elevation is 1,830 meters (5,930 feet) above sea level. The highest point in the watershed is Mount Haggin, at 10,607 feet. The lowest point is the confluence with Flint Creek at the downstream edge of the TPA.

The TPA includes three discrete valleys. These include a high mountain valley (the Summit Valley around Butte), a broad fault-bounded basin (Deer Lodge Valley) and the narrow Clark Fork Valley northwest of Garrison.

2.1.3 Geology

Figure A-5 provides an overview of the geology, based on the 1:500,000 scale statewide map (Ross et al., 1955). Description of the geology is derived from more recent, larger-scale mapping projects. The geology of selected areas of the TPA has been described and mapped in detail by Portner and Hendrix (2005) and Lewis et al. (1998). The geology of the Upper Clark Fork area is complex and beyond the scope of this characterization. In general, the TPA encompasses fault-bounded valleys filled with unconsolidated sediment and the bedrock mountains that surround them.

Bedrock

The Flint Creek Range is composed of folded and faulted sedimentary rocks ranging in age from Cambrian (540 million years ago) through Cretaceous (65 million years ago), with overthrusts of Belt Supergroup rocks mapped in places. The Cretaceous sediments are predominantly fine-grained rocks such as siltstones and shales. This package of sedimentary rocks has been intruded by several generations of Cretaceous and Tertiary igneous rocks. The range is cored by the Philipsburg pluton, a body of resistant Cretaceous granodiorite that holds up the higher peaks. Pleistocene glaciation sculpted the Flint Creek range, producing the rugged alpine geomorphology (Lewis 1998).

The Boulder Mountains are underlain by a large body of granitic igneous rock, called the Boulder Batholith. The batholith is flanked by volcanic rocks of Tertiary age. These mountains are generally lower in elevation and more rounded than the Flint Creek Range.

Basin Sediments

The Deer Lodge Valley features distinctive sloped terraces above the modern fluvial valley, and abutting the mountains. These terraces are composed of Tertiary sediment and are well-drained and sparsely vegetated (Lewis 1998).

In the Northern Rockies, the Tertiary is generally characterized as a time of basin filling, followed by renewed uplift, stream erosion and downcutting in the Quaternary. The basins are filled with several thousand feet of Tertiary basin-fill sediments, with a veneer of overlying Quaternary deposits. Oil wells have reported over 10,000 feet of unconsolidated sediment at the deepest point in the Deer Lodge valley. The narrow Clark Fork Valley between Gold Creek and Drummond is shallower, with bedrock at a depth of roughly 3,000 feet (Kendy and Tresch, 1996). The Summit Valley is a relatively shallow basin, with fewer than 1,000 feet of alluvial deposits at the deepest portion of the basin (LaFave, 2008).

2.1.4 Soils

The USGS Water Resources Division (Schwartz and Alexander, 1995) created a dataset of hydrology-relevant soil attributes, based on the USDA Natural Resources Conservation Service (NRCS) STATSGO soil database. The STATSGO data is intended for small-scale (watershed or larger) mapping, and is too general to be used at scales larger than 1:250,000. It is important to realize, therefore, that each soil unit in the STATSGO data may include up to 21 soil components. Soil analysis at a larger scale should use NRCS SSURGO data. The soil attributes considered in this characterization are erodibility and slope.

Soil permeability is reported in inches per hour, and is mapped on **Figure A-6a.** Impermeable soils are mapped in the vicinity of the Anaconda smelter complex.

Soil erodibility is based on the Universal Soil Loss Equation (USLE) K-factor (Wischmeier & Smith 1978). K-factor values range from 0 to 1, with a greater value corresponding to greater potential for erosion. Susceptibility to erosion is mapped on **Figure A-6b**, with soil units assigned to the following ranges: low (0.0-0.2), low-moderate (0.2-0.29) and moderate-high (0.3-0.4). Values of >0.4 are considered highly susceptible to erosion. No values greater than 0.4 are mapped in the TPA.

Nearly 60% of the TPA is mapped as low-moderately erodible soils. Twenty-three percent of the soils in the TPA are assigned low susceptibility to erosion. The remaining 18% of soils are assigned moderate to high susceptibility to erosion.

Several patterns are apparent in the distribution of mapped K-factors. The low and moderate-to-low susceptibility soils correspond to timbered uplands, and moderate-to-high susceptibility soils are confined to the valleys. Moderate-to-high susceptibility soils coincide with areas where Tertiary sediments are mapped, and the Quaternary alluvial valleys incised into these deposits generally have moderate-to-low susceptibility. The majority of the low-susceptibility soils coincide with the granitic rocks of the Philipsburg pluton and are less strongly associated with the Boulder Batholith.

The steepest slopes in the watershed are in the Flint Creek Range. The Boulder and Garnet Ranges differ by exhibiting rounded summits and broad ridges incised with steeply sloping valleys. The valleys and the terraces east of the Deer Lodge valley are distinguished by large areas of low slope.

A map of slope is provided on **Figure A-7**.

2.1.5 Surface Water

Within the Upper Clark Fork TPA, the Clark Fork River drains from the confluence of Silver Bow Creek and Warm Springs Creek to the confluence with Flint Creek near Drummond, a distance of approximately 64 miles. The Clark Fork River receives one major tributary within the TPA: the Little Blackfoot River. Although this river contributes flow to the Clark Fork

River, the Little Blackfoot watershed is the subject of a separate TPA, and is not considered here. Upper Clark Fork watershed hydrography is illustrated on **Figure A-8**.

Impoundments

Two impoundments are located within the watershed: Silver Lake (277 acres) and Rock Creek Lake (176 acres). Warm Springs Ponds were constructed in the early 20th Century for tailings impoundment, and the resulting surface waters are now a wildlife management area.

Stream Gaging Stations

The United States Geological Survey (USGS) maintains 15 gaging stations within the watershed. An additional 9 gages are now inactive. The USGS gaging stations are listed below (**Table 2-1**, and shown on **Figure A-8.**

Table 2-1. USGS Stream Gages in the Upper Clark Fork

Name	Number	Drainage Area	Agency	Period of Record
Blacktail Creek near Butte	12323200	14.7 miles^2	USGS	1983 - 1988
Blacktail Creek at Butte	12323200	95.4 miles^2	USGS	1988-
Silver Bow Creek above Blacktail Creek	12323170	–	USGS	1983 - 1994
Silverbow Creek below Blacktail Creek	12323250	103 miles^2	USGS	1983-
Silverbow Creek above WWTP	12323248	–	USGS	1998 - 2003
German Gulch near Ramsay	12323500	40.6 miles^2	USGS	1955 - 1969
Willow Creek at Opportunity	12323720	30.8 miles^2	USGS	2003-
Willow Creek near Anaconda	12323710	13.7 miles^2	USGS	2005-
Silverbow Creek at Opportunity	12323600	363 miles^2	USGS	1988-
Mill Creek at Opportunity	12323700	43.2 miles^2	USGS	2003-
Mill Creek Near Anaconda	12323670	34.4 miles^2	USGS	2004-
Warm Springs Creek near Anaconda	12323760	157 miles^2	USGS	1997-
Silver Bow Creek at Warm Springs	12323750	394 miles^2	USGS	1972-
Warm Springs Creek at Warm Springs	12323770	163 miles^2	USGS	1983-
Racetrack Creek near Anaconda	12324000	39.5 miles^2	USGS	1911 - 1912
Racetrack Creek below Granite Creek	12324100	39.5 miles^2	USGS	1957 - 1973
Lost Creek near Anaconda	12323840	26.4 miles^2	USGS	2004-
Lost Creek near Galen	12323850	60.5 miles^2	USGS	2003-
Clark Fork near Galen	12323800	651 miles^2	USGS	1988-
Clark Fork at Deer Lodge	12324200	995 miles^2	USGS	1978-
Clark Fork near Garrison	12324300	1,139 miles^2	USGS	1961
Gold Creek at Goldcreek	12324660	64.1 miles^2	USGS	1963 - 1966
Clark Fork at Goldcreek	12324680	1,760 miles^2	USGS	1977-
Clark Fork near Drummond	12331600	2,378 miles^2	USGS	1972-1983

Stream Flow

Stream flow data are based on records from the USGS stream gauges described above, and are available on the Internet from the USGS (2009). Flows in the Clark Fork River and its tributaries vary considerably over a calendar year. Hydrographs from stations at Clark Fork at Deer Lodge (1979-2009) and Clark Fork at Goldcreek (1979-2009) are included in **Appendix D**.

Discharges in the Clark Fork River statistically peak in June, decline sharply in July and reach lows in August. This pattern is evident at gages from Deer Lodge to Drummond. Water Year 2008 summaries for selected gages are included in **Appendix D.**

Surface Water Quality
Water quality and chemistry data are available from numerous USGS gaging stations in the Upper Clark Fork TPA. This data has been gathered as part of the data compilation process. Surface water quality data from the most recent USGS Water-Data Report (Berkas, 2008) are included in **Appendix D.**

2.1.6 Ground Water

Hydrogeology
Ground water flow within the valleys is typical of intermontane basins. Ground water flows towards the center of the basin from the head and sides, and then down valley along the central axis.

The hydrogeology of the Deer Lodge Valley and the Clark Fork Valley is described in Kendy and Tresch (1996), in discussion of the Upper Clark Fork River basin. The Summit Valley has been characterized in other reports (e.g. Lafave, 2008; Carstarphen et al., 2004).

Natural recharge occurs from infiltration of precipitation, stream loss and flow out of the adjacent bedrock aquifers. Flood irrigation is a major source of recharge to the valley aquifers, and return flows contribute significantly to stream flow (Nimick et al., 1993). The Clark Fork is a gaining stream between Racetrack and Garrison.

Four thermal springs are present in the Deer Lodge valley (Kendy and Tresch, 1996): Warm Springs (78°C), Gregson Hot Springs (70°C), Anaconda Hot Springs (22°C) and Deer Lodge Prison Hot Springs (26°C).

Ground Water Quality
The Montana Bureau of Mines and Geology (MBMG) Ground Water Information Center (GWIC) program monitors and samples a statewide network of wells (MBMG, 2009). Additionally, the GWIC program is engaged in a statewide characterization of aquifers and ground water resources, by region. The TPA is in Region 5, the Upper Clark Fork River basin. Elevated nitrogen levels are well documented in Summit Valley ground water (e.g. Lafave, 2008). The sources are not well understood, but isotopic evidence suggests a large anthropogenic contribution.

As of September 2009, the GWIC database reports 5,755 wells within the TPA (NRIS, 2009). Water quality data is available for 4,245 of those wells. This is an unusually high percentage, related to the extensive ground water investigations related to environmental cleanup efforts. The locations of these data points are shown on **Figure A-9**.

The water quality data include general physical parameters: temperature, pH and specific conductance, in addition to inorganic chemistry (common ions, metals and trace elements). MBMG does not analyze ground water samples for organic compounds.

There are 48 public water supplies within the TPA. The majority of these are small transient, non-community systems (i.e. that serve a dynamic population of more than 25 persons daily) located around Georgetown Lake. The Butte Silverbow Water Department (and systems that purchase water from Butte) uses surface water; all other public water supplies in the TPA utilize ground water. Water quality data is available from these utilities via the SDWIS State database (DEQ, 2009), although the data reflect the finished water provided to users, not raw water at the source.

2.1.7 Stream Morphology

Stream morphology throughout the TPA is variable and has been historically altered in many cases to accommodate a variety of land uses and/or transportation networks. In general, streams in the upper Clark Fork originate in high elevation, steep, mountainous terrain dominated by cobble substrate and are predominantly driven by snowmelt and runoff. In these areas, the streams are entrenched to moderately entrenched and are characterized by cascading step/pool to riffle dominated channels as gradient decreases. In these upper reaches of the streams, channel form and profile are generally very stable. Gradually, these systems transition downstream to meandering, low gradient systems characterized by riffle/pool complexes with well defined point bars and broad, and well developed flood plains. These low gradient, wide valley portions of the upper Clark Fork streams are typically where most alteration to stream morphology has occurred and where the most bank instability and impacts from sediment deposition can be found, when it occurs.

2.1.8 Climate

Climate in the TPA is typical of mid-elevation intermontane valleys in western Montana. The local climate varies with elevation.

Precipitation is most abundant in May and June. Butte receives an annual average of 12.75 inches of moisture, compared to 10.7 reported at Deer Lodge. The mountains may exceed 40 inches average annual moisture (PRISM, 2004). See **Tables 2-3** and **2-3** for climate summaries; **Figure A-10** shows the distribution of average annual precipitation.

Climate Stations

Climate data for the TPA is based upon the stations at Philipsburg and Drummond (although the latter is located outside the TPA). The USDA Natural Resources Conservation Service (NRCS) operates 10 SNOTEL snowpack monitoring stations within the TPA. **Figure A-10** shows the locations of the NOAA and SNOTEL stations, in addition to average annual precipitation. The precipitation data is mapped by Oregon State University's PRISM Group, based on the records from NOAA stations (PRISM, 2004). Climate data is provided by the Western Regional Climate Center, operated by the Desert Research Institute of Reno, Nevada.

Table 2-2. Monthly Climate Summary: Deer Lodge

Deer Lodge 3 W, Montana (242275) Period of Record : 4/ 15/1959 to 12/31/2005

	Jan	**Feb**	**Mar**	**Apr**	**M.ay**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Ave. Max. Temp (F)	32.2	38.1	44.7	54.6	62.9	71.5	80.2	79.9	69.4	58.3	42.3	33.1	55.6
Ave. Min. Temp. (F)	9.1	14.2	19.3	25.7	32.8	39.7	42.9	41.3	33.6	26.0	17.1	10.3	26.0
Ave Tot. Precip. (in.)	0.43	0.32	0.51	0.73	1.84	1.88	1.28	1.31	1.10	0.59	0.41	0.39	10.76
Ave.. Snowfall (in.)	8.7	4.2	7.6	3.5	0.5	0.2	0.0	0.0	0.0	1.1	4.5	6.2	36.4
Ave Snow Depth (in.)	4	2	1	0	0	0	0	0	0	0	1	2	1
Deer Lodge, Montana (242273)Period of Record : 1/1/1893 to 2/28/1959													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Ave. Max. Temp (F)	31.8	35.6	43.0	55.7	64.9	71.7	82.0	80.6	70.1	58.6	42.7	34.4	55.9
Ave. Min. Temp. (F)	10.1	12.4	19.0	28.1	35.4	42.0	46.3	44.8	36.9	28.8	19.6	13.9	28.1
Ave Tot. Precip. (in.)	0.46	0.40	0.57	0.69	1.50	2.30	1.20	0.79	1.01	0.67	0.52	0.52	10.62
Ave.. Snowfall (in.)	5.3	4.4	4.0	1.2	0.8	0.1	0.0	0.0	0.1	1.2	2.8	5.6	25.5
Ave Snow Depth (in.)	2	2	1	0	0	0	0	0	0	0	0	1	1

Table 2-3. Monthly Climate Summary: Butte

Butte FAA Airport, Montana (241318) Period of Record : 4/2/1894 to 12/31/2005

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Ave. Max. Temp (F)	30.0	34.3	40.9	51.1	60.5	69.4	79.7	78.2	66.9	55.5	40.6	31.7	53.2
Ave. Min. Temp. (F)	7.4	10.7	17.7	27.1	34.8	41.9	47.0	45.2	36.8	28.5	18.1	9.9	27.1
Ave Tot. Precip. (in.)	0.61	0.53	0.80	1.07	1.91	2.27	1.27	1.16	1.12	0.79	0.63	0.60	12.75
Ave. Snowfall (in.)	8.5	7.3	10.2	6.9	3.7	0.5	0.0	0.1	1.1	3.7	6.5	8.4	56.8
Ave Snow Depth (in.)	4	4	2	0	0	0	0	0	0	0	1	2	1

2.2 Ecological Parameters

2.2.1 Vegetation

The primary cover in the uplands is conifer forest. Conifers are dominated by Lodgepole pine, giving way to Douglas fir and Ponderosa pine at lower elevations. The valleys are characterized by grassland and irrigated agricultural land, and shrublands dominate the Tertiary benches. Landcover and land use are shown on Figures **A-11** and **A-12**. Data sources include the University of Montana's Satellite Imagery land Cover (SILC) project (University of Montana, 2002), and USGS National Land Cover Dataset (NLCD) mapping (USGS, 2001).

2.2.2 Aquatic Life

Native fish species present in the TPA include: bull trout, westslope cutthroat trout, mountain whitefish, longnose dace, mottled scuplin, slimy scuplin, northern pike minnow, redside shiner, largescale sucker and longnose sucker. Bull trout and westslope cutthroat trout are designated "Species of Concern" by Montana Department of Fish, Wildlife and Parks (FWP). Bull trout are further listed as "threatened" by the US Fish and Wildlife Service (US FWS). Reaches of Racetrack creek, Warm Springs Creek, and its tributaries have been designated as critical habitat for bull trout (US FWS, 2005).

Bull trout are mapped in the Clark Fork River, and in some tributary streams draining the Flint Creek Range: Racetrack, Lost and Warm Springs creeks. Bull trout are also mapped in the headwaters tributaries of Warm Springs Creek (Barker, Twin Lakes, Storm Lake, Cable and Foster creeks. Bull trout are not mapped in any streams that drain from the Boulder Mountains. Westslope cutthroat trout are not reported in the Clark Fork River, but are mapped in the upper reaches of most tributaries. Neither bull trout nor westslope cutthroat trout are reported in Mill and Willow creeks.

Introduced species present in the TPA include: brook, brown and rainbow trout, common carp, pumpkinseed, largemouth bass and yellow perch.

Data on fish species distribution is collected, maintained and provided by FWP (2006). Distribution of bull trout, westslope cutthroat trout, and introduced species is shown in **Figure A-13**.

2.2.3 Fires

The United States Forest Service (USFS) remote sensing applications center provides data on fire locations from the 19th Century to the present (**Figure A-14**).

In general, the TPA has not experienced significant burns in recent years. Small fires occurred in 1987, 1988, 1990, 2003 and 2009. The 2009 Bielenburg fire is the largest, at over 1,600 acres. All other fires burned less than 200 acres.

2.3 Cultural parameters

2.3.1 Population

An estimated 50,000 persons lived within the TPA in 2000 (NRIS, 2009). The densest populations are located in the urban areas of Butte, Deer Lodge and Anaconda (**Figure A-15**).

2.3.2 Land Ownership

Slightly more than one-half of the TPA is under private ownership. The dominant landholder is the USFS, which administers 30% of the TPA. There is a distinct pattern of ownership, with private land concentrated in the basins and USFS land concentrated in the uplands (**Figure A-16**).

Table 2-4. Land Ownership

Owner	**Acres**	**Square Miles**	**% of Total**
Private	554,586	866.5	58.0%
US Forest Service	281,530	439.9	29.5%
US Bureau of Land Management	9,843	15.4	2.7%
State Trust Land	37,063	57.9	3.9%
Montana FWP	35,992	56.2	3.8%
MT Department of Corrections	34,005	53.1	3.6%
Other State Land	113	0.2	0.1%
Water	844	1.3	0.9%
Total	955,622	497.7	—

2.3.3 Land Use

Land use within the TPA is dominated by forest and agriculture. Agriculture in the lowlands is primarily related to the cattle industry: irrigated hay and dry grazing. Information on land use is based on the USGS National Land Cover Dataset (USGS, 2001). The data are at 1:250,000 scale. Agricultural land use is illustrated on **Figure A-17.**

Table 2-5. Land Use and Land Cover

Land Use	**Acres**	**Square Miles**	**% of Total**
Evergreen Forest	412,819	645.0	43.2%
Grassland/Herbaceous	223,027	348.5	23.3%
Scrub/Shrub	194,427	303.8	20.3%
Pasture/Hay	44,885	70.1	4.7%
Cultivated Crops	19,557	30.6	2.0%
Developed Open Space	16,512	25.8	1.7%
Developed Low Intensity	9,216	14.4	1.0%
Woody Wetlands	9,215	14.4	1.0%
Barren Land	7,052	11.0	0.7%
Developed Medium Intensity	5,121	8.0	0.5%
Paved Roads	4,239	6.6	0.4%
Open Water	3,835	6.0	0.4%
Unpaved Roads	3,766	5.9	0.4%
Lawns	995	1.6	0.1%
Developed High Intensity	421	0.7	0.0%
Hobby Farms	138	0.2	0.0%
Septic System Drainfields	137	0.2	0.0%
Mixed Forest	89	0.1	0.0%
Perennial Ice/Snow	73	0.1	0.0%
Deciduous Forest	60	0.1	0.0%
Emergent Herbaceous Wetlands	3	0.0	0.0%

More detailed information on agricultural land use can be obtained from the United Stated Department of Agriculture data. Cultivated crops are not extensive in the TPA. Barley, wheat, potatoes, corn, dry beans and oats are all reported, but the total acreage for these crops is only 3,162 acres. The USDA cropland data layer reports 11,256 acres of alfalfa in the TPA, land that is likely irrigated. Irrigation infrastructure, including diversions and ditch networks are described in an assessment attached as **Appendix H**.

2.3.4 Transportation Networks

Transportation networks (road and railroads) are illustrated on **Figure A-18**.

Roads
The principal transportation routes in the TPA are US Interstates 90 and 15, US Highway 12 and Montana Highway 1. Using estimates from watershed modeling efforts, an estimated 700 miles of paved roads and 2,500 miles of unpaved roads are present in the TPA (DEQ, 2007). The network of unpaved roads on public and private lands will be further characterized as part of the source assessment.

Railroads
Several active railways are present in the TPA, although rail traffic is reduced from the years when mining, milling and smelting were practiced in the TPA. A Montana Rail Link (MRL) line descends the Little Blackfoot valley and continues west to Missoula. The Burlington Northern Santa Fe (BNSF) railroad maintains a branch line between Butte and Garrison. A Union Pacific line crosses Deer Lodge Pass and joins the BNSF line at Silver Bow. The former Butte, Anaconda and Pacific line is now operated as a passenger/entertainment railroad by the Rarus Railway Company.

2.3.5 Mining

The Upper Clark Fork TPA was the scene of mining, milling and smelting on a scale of national importance. Like many other mining districts, the metal production began with gold placers in the 1860s, although lode mines soon began to exploit rich silver deposits. Copper came to dominate the Butte mines by the 1880s. Smelters were located in Butte, Anaconda and Garrison. Waste from the mines, mills and smelters was deposited in and near streams. Significant amounts of mine waste were later mobilized by floods and redeposited along the floodplains of Silver Bow Creek and the Clark Fork River.

The environmental impacts from a century of mining activity were severe and have been extensively researched in conjunction with remediation efforts under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), commonly known as the "Superfund".

The Butte/Silver Bow Creek and Anaconda sites were added to the US EPA's CERCLA National Priority List (NPL) in 1983. The former extends from the headwaters of Silver Bow Creek to Warm Springs Ponds. The Anaconda site includes a 300 mile footprint around the former smelter. The portion of the Clark Fork River from the Warm Springs Ponds outlet to Milltown Reservoir was added to the NPL in 1992. Together, the sites are contiguous from the Continental Divide to below the downstream end of the TPA (US EPA, 2009).

Butte/Silver Bow Creek CERCLA Site

Waste rock and smelter tailings were formerly deposited in and along Silver Bow Creek, and floods subsequently redeposited these materials along the floodplain. The site also includes the cities of Butte and Walkerville, as well as the Berkeley Pit former mine site and the interconnected mine workings. The site is subdivided into eight remedial operable units. Remedial progress on the site varies by operable unit. US EPA has issued records of decision (RODs) for five of the operable units. Remedial action has been completed for the Warm Springs Ponds Operable Unit and is on-going for the Lower Area One, Rocker Timber and Framing, Streamside Tailings, and Mine Flooding operable units. Remedial action involves removal of tailings deposits and waste rock from the floodplain of Silver Bow Creek, floodplain reconstruction, land reclamation, ground water and storm water controls and water treatment. Remedial activities at the Silver Bow Creek/Butte Area Superfund Site have and will continue to improve the water quality and ecological health of Silver Bow Creek.

Anaconda Smelter CERCLA Site

The Anaconda smelters operated from the mid 1880s to 1980. Milling and smelting produced wastes with high concentrations of arsenic, as well as copper, cadmium, lead and zinc. These contaminants pose potential risks to human health and the environment. The site is subdivided into five remedial operable units. US EPA has issued RODs for all five operable units. Remedial activities planned for the Anaconda Smelter site include land reclamation for large tailings ponds (>4,000 acres) and landscapes contaminated by aerial emissions, stream stabilization and storm water best management practices.

Milltown Reservoir / Clark Fork River CERCLA Site

Only one operable unit of this CERCLA site is within the TPA boundary: Clark Fork River. The other (Milltown Reservoir Sediments) is downstream of the TPA. Remedial activities planed for the river include removal of some exposed tailings, in-place reclamation of some exposed tailings or other tailings-impacted soils, stream bank stabilization and development of a riparian corridor buffer. Sediments from the drained Milltown Reservoir were transported to the Anaconda Smelter CERCLA site in 2007-2009.

Many smaller mines were operated in the tributary watersheds, particularly in the Flint Creek Range as shown on **Figure A-19**. Smaller inactive and abandoned mines located on Beaverhead-Deer Lodge National Forest lands were catalogued in a report by Madison et al. (1998). Abandoned mines located in watersheds draining to metals-listed streams are shown on **Figure A-19**. This report identified 20 sites with water-quality exceedences for metals (based on the dissolved metals fractions). Potential impacts from abandoned mines on private land were not assessed.

Within metals-listed watersheds, the TPA includes 2 abandoned mines on DEQ's Priority Abandoned Mines list; 105 mines in DEQ's inventory; and 272 mines in MBMG's inventory.

2.3.6 Industry

Butte was once the largest city in Montana and hosted other industries besides mining. There are two industrial operations with Montana Pollutant Discharge Elimination System (MPDES) storm water permits (**Figure A-19)**. They include AFFCO (MTR000068), which discharges to lower Warm Springs Creek, and Sun Mountain Lumber (MTR000296), which discharges to Tin Cup Joe Creek. Additionally, there is an FWP-owned fish farm with an MPDES permit. It is the Washoe Park Trout Hatchery (MTG130013), and it discharges to Warm Springs Creek. Permitted discharges outside of 303(d) listed watersheds addressed within this document are not shown.

Montana Pole and Treating Plant CERCLA Site
The Montana Pole wood treating facility in Butte was listed on the NPL in the 1980s following complaints of organic chemicals discharging to Silver Bow Creek. The Montana Pole and Treating Plant (MPTP) site is located in the southwestern corner of Butte and is the location of a former wood treating facility that operated from 1946 to 1983. Contamination of soils, ground water, and nearby Silver Bow Creek occurred from treating fluids containing pentachlorophenol (PCP) that were used and disposed of on site.

The site was added to the NPL in 1987. In 1993, DEQ and US EPA issued a ROD. Phase 1, Phase 2 and Phase 3 have been completed and included the removal and treatment of contaminated soils and debris. Phase 4 involves on-going biological treatment of contaminated soils at the site and Phase 5 addresses the remaining contaminated soils beneath Interstate 15/90 that transects the site.

Contaminated ground water is intercepted in two trenches, treated with granular activated carbon at an onsite treatment plant, and discharged to Silver Bow Creek. One trench, the Near Highway Recovery Trench, is located immediately north of Interstate Highway I-15/90. The second trench, the Near Creek Recovery Trench, is located at the north boundary of the site, just south of Silver Bow Creek (US EPA, 2009).

2.3.7 Livestock Operations

There is one MPDES-permitted confined animal feeding operation (CAFO) near a 303(d) listed water body in the TPA: the Montana State Prison ranch outside of Deer Lodge near Tin Cup Joe Creek (**Figure A-19**). Many livestock operations not subject to MPDES permits are also present in the TPA.

2.3.8 Wastewater

Four wastewater outfalls are located within the TPA (i.e. Butte-Silverbow, Rocker, State Hospital at Warm Springs, and Deer Lodge), but none of them discharge to water bodies being addressed within this document.

SECTION 3.0
TMDL REGULATORY FRAMEWORK

3.1 TMDL Development Requirements

Section 303(d) of the Federal Clean Water Act (CWA) requires states to identify water bodies within its boundaries that do not meet water quality standards. States track these impaired or threatened water bodies with a 303(d) List. Recently the name for the 303(d) List has changed to Category 5 of Montana's Water Quality Integrated Report. State law identifies that a consistent methodology is used for determining the impairment status of each water body. The impairment status determination methodology is identified in **Appendix A** of Montana's Water Quality Integrated Report (DEQ, 2006).

Under Montana State Law, an "impaired water body" is defined as a water body or stream segment for which sufficient credible data show that the water body or stream segment is failing to achieve compliance with applicable water quality standards (Montana Water Quality Act; Section 75-5-103(11)). A "threatened water body" is defined as a water body or stream segment for which sufficient credible data and calculated increases in loads show that the water body or stream segment is fully supporting its designated uses but threatened for a particular designated use because of: (a) proposed sources that are not subject to pollution prevention or control actions required by a discharge permit, the nondegradation provisions, or reasonable land, soil, and water conservation practices; or (b) documented adverse pollution trends (Montana Water Quality Act; Section 75-5-103(31)). State Law and section 303 of the CWA require states to develop TMDLs for impaired or threatened water bodies.

A TMDL is a pollutant budget for a water body identifying the maximum amount of the pollutant that a water body can assimilate without causing applicable water quality standards to be exceeded. TMDLs are often expressed in terms of an amount, or load, of a particular pollutant (expressed in units of mass per time such as pounds per day). TMDLs must account for loads/impacts from point and nonpoint sources in addition to natural background sources, and need to incorporate a margin of safety and consider seasonality. In Montana, TMDL development is often accomplished in the context of an overall water quality plan. The water quality plan includes not only the actual TMDL, but also includes information that can be used to effectively restore beneficial water uses that have only been affected by pollution, such as habitat degradation or flow modification that are not covered by the TMDL program.

To satisfy the Federal Clean Water Act and Montana State Law, TMDLs are developed for each water body-pollutant combination identified on the states list of impaired or threatened waters and are often presented within the context of a water quality restoration or protection plan. State Law (Administrative Rules of Montana 75-5-703(8)) also directs DEQ to "support a voluntary program of reasonable land, soil, and water conservation practices to achieve compliance with water quality standards for nonpoint source activities for water bodies that are subject to a TMDL ……" This is an important directive that is reflected in the overall TMDL development and implementation strategy within this plan. It is important to note that water quality protection measures are not considered voluntary where such measures are already a requirement under existing Federal, State, or Local regulations. Montana TMDL laws provide a 5-year review process to allow for an adaptive management approach to update the TMDL and water quality restoration plan.

3.2 Water Bodies and Pollutants of Concern

Recently, a court ruling and subsequent settlements have obligated the U.S. EPA and the State of Montana to use pollutant/water body combinations from the Montana's 1996 List of impaired waters. State and federal guidance indicates that the most recent list be used for determining the need for TMDLs. Sediment, metals and temperature pollutants that have appeared on the 2008 list are addressed in the impairment status review, TMDLs, or watershed restoration plans presented in this document. Most pollutants identified on the 2008 list are addressed; however a few of them are not addressed at this time due to project budget and time constraints. These listings will be identified in a follow up monitoring strategy and addressed within a timeframe identified in Montana's law (*Montana Code Annotated 75-5-703*). However, TMDLs were not prepared for impairments where additional information suggests that the initial listings were inaccurate, or where conditions had improved sufficiently since the listing to an extent that the pollutant no longer impairs a beneficial use. Where a pollutant is recommended for removal from the list, justification is provided in the sections that follow. **Table 3-1** provides a summary of water body listings and their beneficial use support status for the 2008 303(d) Lists for the Upper Clark Fork TPA. Specific probable causes of impairment for each of the impaired water bodies is found in **Table 1-1**, in **Section 1**.

Table 3-1. Upper Clark Fork impaired water body segments and beneficial use support status

Water Body & Stream Description	Water Body #	Use Class	Aquatic Life	Fisheries - Cold	Drinking Water	Primary Contact (Recreation)	Agriculture	Industry
Antelope Creek, headwaters to mouth (Gardner Gulch)	MT76G003_031	B-1	X	X	F	P	F	F
Beefstraight Creek, Minnesota Gulch to mouth (German Gulch)	MT76G003_031	B-1	N	N	X	X	X	X
Brock Creek, headwaters to mouth (Clark Fork River)	MT76G005_100	B-1	X	X	F	P	F	F
Cable Creek, the headwaters to the mouth (Warm Springs Creek)	MT76G002_030	B-1	P	P	F	P	F	F
Dempsey Creek, the national forest boundary to the mouth (Clark Fork River)	MT76G002_100	B-1	P	P	F	P	F	F
Dunkleberg Creek, headwaters SW corner Sec 2, T9N, R12W	MT76G005_071	B-1	N	N	N	P	F	F
Dunkleberg Creek, SW corner Sec 2, T9N, R12W to mouth (Clark Fork River)	MT76G005_072	B-1	P	P	F	F	F	F
German Gulch, headwaters to mouth (Silver Bow Creek)	MT76G003_030	B-1	N	N	F	F	F	F
Gold Creek, headwaters to the Natl. Forest boundary	MT76G005_091	B-1	N	N	N	F	F	F

Table 3-1. Upper Clark Fork impaired water body segments and beneficial use support status

Water Body & Stream Description	**Water Body #**	**Use Class**	**Aquatic Life**	**Fisheries - Cold**	**Drinking Water**	**Primary Contact (Recreation)**	**Agriculture**	**Industry**
Gold Creek, the forest boundary to the mouth (Clark Fork River)	MT76G005_092	B-1	P	P	F	P	F	F
Hoover Creek, headwaters to Miller Lake	MT76G005_081	B-1	X	X	X	P	X	X
Hoover Creek, Miller Lake to mouth (Clark Fork)	MT76G005_082	B-1	N	N	X	N	X	X
Lost Creek, the south State Park boundary to the mouth (Clark Fork River)	MT76G002_072	B-1	N	N	N	P	F	F
Mill Creek, headwaters to the section line between Sec 27 & 28, T4N, R11W	MT76G002_051	B-1	P	P	F	F	F	F
Mill Creek, section line between Sec 27 & 28, T4N, R11W to the mouth (Silver Bow Creek)	MT76G002_052	B-1	N	N	N	P	P	F
Mill-Willow Bypass, from Silver Bow Creek to the Clark Fork River	MT76G002_120	B-1	P	P	N	F	F	F
Modesty Creek, headwaters to the mouth (Clark Fork River)	MT76G002_080	B-1	X	X	N	P	F	F
Peterson Creek, headwaters to Jack Creek	MT76G002_131	B-1	N	N	F	P	F	F
Peterson Creek, Jack Creek to the mouth (Clark Fork River)	MT76G002_132	B-1	N	N	X	N	X	X
Racetrack Creek, the national forest boundary to the mouth (Clark Fork River)	MT76G002_090	B-1	P	P	F	P	F	F
Storm Lake Creek, headwaters to mouth (Warm Springs Creek)	MT76G002_040	B-1	P	P	F	P	F	F
Tin Cup Joe Creek, Tin Cup Lake to mouth (Clark Fork River)	MT76G002_110	B-1	N	N	F	N	F	F
Warm Springs Creek, (Near Phosphate), headwaters to the line between R9W and R10W	MT76G005_111	B-1	P	P	F	F	F	F
Warm Springs Creek, (Near Phosphate) from line between R9W and R10W to mouth (Clark Fork River)	MT76G005_112	B-1	P	P	F	P	F	F
Warm Springs Creek, (near Warm Springs), headwaters to Meyers Dam (T5N, R12W, SEC 25)	MT76G002_011	B-1	P	P	F	F	F	F
Warm Springs Creek, (near Warm Springs), Meyers Dam (T5N, R12W, SEC 25) to mouth (Clark Fork)	MT76G002_012	B-1	N	N	N	P	F	F
Willow Creek, headwaters to T4N, R10W, Sec30 (DABC)	MT76G002_061	B-1	N	N	N	P	F	F
Willow Creek, T4N, R10W, Sec30 (DABC) to mouth (Silver Bow Creek)	MT76G002_062	B-1	N	N	N	F	F	F

Legend
F= Full Support; **P**= Partial Support; **N**= Not Supported; **T**= Threatened; **X**= Not Assessed (Insufficient Credible Data)

Impairment status and impairment list reviews are provided for each water body in **Sections 5.0**, **6.0** and **7.0** of this document.

3.3 Applicable Water Quality Standards

Water quality standards include: the uses designated for a water body, the legally enforceable standards that ensure that the uses are supported, and a nondegradation policy that protects the high quality of a water body. The ultimate goal of this water quality restoration plan, once implemented, is to ensure that all designated beneficial uses are fully supported and all standards are met. Water quality standards form the basis for the targets described in **Sections 5**, **6** and **7**. Pollutants addressed in this Water Quality Restoration Plan include: sediment, metals, and temperature. This section provides a summary of the applicable water quality standards for each of these pollutants.

3.3.1 Classification and Beneficial Uses

Classification is the assignment (designation) of a single or group of uses to a water body based on the potential of the water body to support those uses. Designated Uses or Beneficial Uses are simple narrative descriptions of water quality expectations or water quality goals. There are a variety of “uses” of state waters including: growth and propagation of fish and associated aquatic life; drinking water; agriculture; industrial supply; and recreation and wildlife. The Montana Water Quality Act (WQA) directs the Board of Environmental Review (BER, i.e., the state) to establish a classification system for all waters of the state that includes their present (when the Act was originally written) and future most beneficial uses (Administrative Rules of Montana (ARM) 17.30.607-616), and to adopt standards to protect those uses (ARM 17.30.620-670).

Montana, unlike many other states, uses a watershed based classification system with some specific exceptions. As a result, *all* waters of the state are classified and have designated uses and supporting standards. All classifications include multiple uses and in only one case (A-Closed) is a specific use (drinking water) given preference over the other designated uses. Some waters may not actually be used for a specific designated use, for example as a public drinking water supply; however, the quality of that water body must be maintained suitable for that designated use. When natural conditions limit or preclude a designated use, permitted point source discharges or nonpoint source discharges may not make the natural conditions worse.

Modification of classifications or standards that would lower a water’s classification or a standard (i.e., B-1 to a B-3), or removal of a designated use because of natural conditions can only occur if the water was originally mis-classified. All such modifications must be approved by the BER, and are undertaken via a Use Attainability Analysis (UAA) that must meet U.S. EPA requirements (40 CFR 131.10(g), (h) and (j)). The UAA and findings presented to the BER during rulemaking must prove that the modification is correct and all existing uses are supported. An existing use cannot be removed or made less stringent.

All tributaries included in this document have been designated as B-1. A description of Montana’s applicable surface water classifications and designated beneficial uses for Upper Clark Fork tributaries are presented in **Table 3-2**.

Table 3-2. Montana Surface Water Classifications and Designated Beneficial Uses Applicable to the Upper Clark Fork Tributaries.

Classification	Designated Uses
B-1 CLASSIFICATION:	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

3.3.2 Standards

In addition to the Use Classifications described above, Montana's water quality standards include numeric and narrative criteria as well as a nondegradation policy.

Numeric surface water quality standards have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular WQB-7 (DEQ, January 2004). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful and have been established at levels to be protective of long-term (i.e., life long) exposure by water consumption, as well as through direct contact such as swimming.

The numeric aquatic life standards include chronic and acute values that are based on extensive laboratory studies that include a wide variety of potentially affected species, a variety of life stages and durations of exposure. Chronic aquatic life standards are protective of long-term exposure to a parameter. The protection afforded by the chronic standards includes detrimental effects to reproduction, early life stage survival and growth rates. In most cases the chronic standard is more stringent than the corresponding acute standard. Acute aquatic life standards are protective of short-term exposures to a parameter and are not to be exceeded.

High quality waters are afforded an additional level of protection by the nondegradation rules (ARM 17.30.701 et. seq.,) and in statute (75-5-303 MCA). Changes in water quality must be "non-significant" or an authorization to degrade must be granted by the Department. However under no circumstance may standards be exceeded. It is important to note that, waters that meet or are of better quality than a standard are high quality for that parameter, and nondegradation policies apply to new or increased discharges to that the water body.

Narrative standards have been developed for substances or conditions for which sufficient information does not exist to develop specific numeric standards. The term "Narrative Standards" commonly refers to the General Prohibitions in ARM 17.30.637 and other descriptive portions of the surface water quality standards. The General Prohibitions are also called the "free from" standards; that is, the surface waters of the state must be free from substances attributable to discharges, including thermal pollution, that impair the beneficial uses of a water body. Uses may be impaired by toxic or harmful conditions (from one or a combination of parameters) or conditions that produce undesirable aquatic life. Undesirable aquatic life includes bacteria, fungi and algae.

The standards applicable to the list of pollutants addressed in the Upper Clark Fork TPA are summarized, one-by-one, below.

Sediment

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table 3-3**. The relevant narrative criteria do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. This is interpreted to mean that water quality goals should strive toward a reference condition that reflects a water body's greatest potential for water quality given current and historic land use activities where all reasonable land, soil, and water conservation practices have been applied and resulting conditions are not harmful, detrimental or injurious to beneficial uses (see definitions in **Table 3-3**).

Table 3-3. Applicable Rules for Sediment Related Pollutants.

Rule(s)	Standard
17.30.623(2)	No person may violate the following specific water quality standards for waters classified B-1.
17.30.623(2)(f)	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except a permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
17.30.637(1)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will.
17.30.637(1)(a)	Settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines.
17.30.637(1)(d)	Create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.
	The maximum allowable increase above naturally occurring turbidity is: 0 NTU for A-closed; 5 NTU for A-1, B-1, and C-1; 10 NTU for B-2, C-2, and C-3)
17.30.602(17)	"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied.
17.30.602(21)	"Reasonable land, soil, and water conservation practices" means methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include but are not limited to structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities.

Metals

Numeric standards for water column metals in Montana include specific standards for the protection of both aquatic life and human health. Acute and chronic criteria have been established for the protection of aquatic life. The criteria for some metals vary according to the hardness of the water. The applicable numeric metals standards (guidelines for aquatic life) for the specific metals of concern in the Upper Clark Fork TPA are presented in **Table 3-4**. Actual standards for aquatic life at any given hardness are calculated using Equation 3-1 and **Table 3-5**. The actual standards are used to determine standards exceedences in this document, not the guidance from **Table 3-5**. Existing data indicates that other metals are below water quality standards.

It should be noted that recent studies have indicated in some streams metals concentrations may vary through out the day because of diel pH and alkalinity changes. In some cases the variation can cross the standard threshold (both ways) for a metal. Montana water quality standards are not time of day dependent.

Table 3-4. Montana Numeric Surface Water Quality Standards Guide for Metals.

Parameter	**Aquatic Life (acute) (µL)[a]**	**Aquatic Life (chronic) (µL)[b]**	**Human Health (µL)[a]**
Aluminum (TR)	750	87	---
Arsenic (TR)	340	150	10
Cadmium (TR)	0.52 @ 25 mg/l hardness	0.097 @ 25 mg/l hardness	5
Chromium (TR)	---	---	100
Copper (TR)	3.79 @ 25 mg/l hardness	2.85 @ 25 mg/l hardness	1,300
Cyanide (TR)	22	5.2	140
Iron (TR)	---	1,000	300d
Lead (TR)	13.98 @ 25 mg/l hardness	0.545 @ 25 mg/l hardness	15
Manganese (TR)	---	---	50
Selenium (TR)	20	5	50
Zinc (TR)	37 @ 25 mg/l hardness	37 @ 25 mg/l hardness	2,000

[a] Maximum allowable concentration.
[b] No 4-day (96-hour) or longer period average concentration may exceed these values.
[c] Standard is dependent on the hardness of the water, measured as the concentration of $CaCO_3$ (mg/L) (see Table 3-5 for the coefficients to calculate the standard).
d The concentration of iron must not reach values that interfere with the uses specified in the surface and ground water standards (17.30.601 et seq. and 17.30.1001 et seq.) The Secondary Maximum Contaminant Level (listed) is based on aesthetic properties such as taste, odor, and staining may be considered as guidance to determine the levels that will interfere with the specified uses.
e The concentration of manganese must not reach values that interfere with the uses specified in the surface and ground water standards (17.30.601 et seq. and 17.30.1001 et seq.). The Secondary Maximum Contaminant Level (listed) is based on aesthetic properties such as taste, odor, and staining may be considered as guidance to determine the levels that will interfere with the specified uses.
Note: TR – total recoverable.

Hardness-based standards for aquatic criteria are calculated using the following equation and are used for determining impairment:

Equation 3-1.

Chronic = exp.{mc[ln(hardness)]+bc} where mc and bc are values from **Table 3-5**

Table 3-5. Coefficients for Calculating Metals Freshwater Aquatic Life Standards (DEQ 2002).

Parameter	ma (acute)	ba (acute)	mc (chronic)	bc (chronic)
Cadmium	1.0166	-3.924	0.7409	-4.719
Copper	0.9422	-1.700	0.8545	-1.702
Lead	1.273	-1.46	1.273	-4.705
Zinc	0.8473	0.884	0.8473	0.884

Note: If hardness is <25 mg/L as CaCO3, 25 must be used for the hardness value in the calculation. If hardness is equal or greater than 400 mg/L as CaCO3, 400 mg/L must be used for the hardness value.

Montana also has a narrative standard that pertains to metals in sediment. No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife (ARM 17.30.623(2)(f)). This narrative standard includes metals laden sediment.

pH

Water bodies impaired by metals are also sometimes impaired by pH as a result of acid mine drainage. For human health, changes in pH are addressed by the general narrative criteria in ARM 17.30.601 et seq. and ARM 17.30.1001 et seq. For aquatic life, which can be sensitive to small pH changes, criteria are specified for each water body use classification. For B-1 waters, ARM 17.30.623 (2)(c) states "Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 must be less than 0.5 pH unit. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0."

Temperature

Montana's temperature standards address a maximum allowable increase above "naturally occurring" temperatures to protect the existing temperature regime for fish and aquatic life. Additionally, Montana's temperature standards address the maximum allowable rate at which temperature changes (i.e., above or below naturally occurring) can occur to avoid fish and aquatic life temperature shock.

For waters classified as A-1, or B-1 the maximum allowable increase over naturally occurring temperature (if the naturally occurring temperature is less than 67º Fahrenheit) is 1° (F) and the rate of change cannot exceed 2°F per hour. If the natural occurring temperature is greater than 67ºF, the maximum allowable increase is 0.5ºF (ARM 17.30.622(e), ARM 17.30.623(e)).

3.3.3 Reference Approach for Narrative Standards

When possible, a reference site approach is used to determine the difference between an impacted area and a "natural" or least impacted water body. The reference site approach is the preferred method to determine natural conditions, but when appropriate reference sites are not easily found, modeling, or regional reference literature values are used. The approach for using reference sites for the Upper Clark Fork TPA is included in **Appendix B**.

SECTION 4.0
DESCRIPTION OF TMDL COMPONENTS

A TMDL is the pollutant loading capacity for a particular water body and refers to the maximum amount of a pollutant a stream or lake can receive and still meet water quality standards. Therefore, when a TMDL is exceeded, the water body will be impaired.

More specifically, a TMDL is the sum of the allowable loading from all sources to the water body. These loads are applied to individual sources or categories of sources as a logical method to allocate water quality protection responsibilities and overall loading limits within the contributing watershed(s). The allocated loads are referred to as waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources. Natural background loading is considered a type of nonpoint source and therefore represents a specific load allocation. In addition, the TMDL includes a Margin of Safety (MOS) that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving stream. The inclusion of a MOS results in less load allocated to one or more WLAs or LAs to help ensure attainment of water quality standards.

TMDLs are expressed by the following equation which incorporates the above components:

$$\text{TMDL} = \Sigma\text{WLA} + \Sigma\text{LA} + \text{MOS}$$

The allowable pollutant load must ensure that the water body being addressed by the TMDL will be able to attain and maintain water quality standards for all applicable seasonal variations in streamflow, and pollutant loading. **Figure 4-1** is a schematic diagram illustrating how numerous sources contribute to the existing load and how the TMDL is defined. The existing load can be compared to the allowable load to determine the amount of pollutant reduction needed.

The major components that go into TMDL development are target development, source quantification, establishing the total allowable load, and allocating the total allowable load to sources. Although the way a TMDL is expressed may vary by pollutant, these components are common to all TMDLs, regardless of pollutant. Each component is described in further detail below.

Each of the following four sections of the document (**Sections 5–7**) are organized by the three pollutants of concern in the Upper Clark Fork TPA: sediment, temperature, and metals. Each section includes a discussion on the water body segments of concern, how the pollutant of concern is impacting beneficial uses, the information sources and assessment methods to evaluate stream health and pollutant source contributions, water quality target development along with a comparison of existing conditions to targets, quantification of loading from identified sources, the determination of the allowable loading (TMDL) for each water body, and the allocations of the allowable loading to sources.

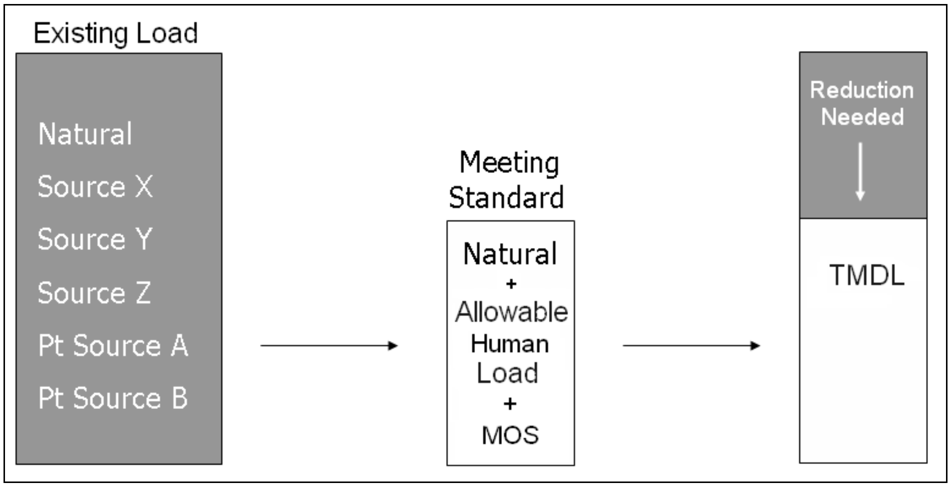


Figure 4-1. Schematic example of TMDL development

4.1 Target Development

Because loading capacity is evaluated in terms of meeting water quality standards, quantitative water quality targets are developed to help assess the condition of the water body relative to the applicable standard(s) and to help determine successful TMDL implementation. This document outlines water quality targets for each pollutant of concern in the Upper Clark Fork TPA. TMDL water quality targets help translate the applicable numeric or narrative water quality standards for the pollutant of concern. For pollutants with established numeric water quality standards, the numeric value(s) within the standard(s) are used as TMDL water quality targets. For pollutants with only narrative standards, the water quality targets provide a site-specific interpretation of the narrative standard(s), along with an improved understanding of impairment conditions. Water quality targets typically include a suite of in-stream measures that link directly to the impacted beneficial use(s) and applicable water quality standard(s). The water quality targets help define the desired stream conditions and are used to provide benchmarks to evaluate overall success of restoration activities. By comparing existing stream conditions to target values, there will be a better understanding of the extent and severity of the problem.

4.2 Quantifying Pollutant Sources

All significant pollutant sources, including natural background loading, are quantified so that the relative pollutant contributions can be determined. Source assessments often have to evaluate the seasonal nature and ultimate fate of the pollutant loading since water quality impacts can vary throughout the year. The source assessment usually helps to further define the extent of the problem by putting human caused loading into context with natural background loading.

A pollutant load is usually quantified for each point source of the pollutant permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. Most other pollutant sources, typically referred to as nonpoint sources, are quantified by source categories such as unpaved roads and/or by land uses such as crop production or forestry. These source categories or land uses can be further divided by ownership such as Federal, State, or private.

Alternatively, a sub-watersheds or tributaries approach can be used, whereby most or all sources in a sub-watershed or tributary are combined for quantification purposes.

The source assessments are performed at a watershed scale because all potentially significant sources of the water quality problems must be evaluated. The source quantification approaches may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading (40CFR Section 130.2(I)). Montana TMDL development often includes a combination of approaches depending on the level of desired certainty for setting allocations and guiding implementation activities.

4.3 Establishing the Total Allowable Load

Identifying the TMDL requires a determination of the total allowable load over the appropriate and sensible time period necessary to comply with the applicable water quality standard(s). Although the concept of allowable daily load is incorporated into the TMDL term, a daily loading period may not be consistent with the applicable water quality standard(s) or may not be practical from a water quality management perspective. Therefore, the TMDL will ultimately be defined as the total allowable loading using a time period consistent with the application of the water quality standard(s) and consistent with established approaches to properly characterize, quantify, and manage pollutant sources in the watershed. For example, sediment TMDLs may be expressed as an allowable yearly load whereas the TMDL to address acute toxicity criteria for metals will include a near-instantaneous loading requirement calculated over a time period of one second (based on standard methods for evaluation flow in cubic feet per second).

Where numeric water quality standards exist for a stream, the TMDL or allowable loading, typically represents the allowable concentration multiplied by the flow of water over the time period of interest. This same approach can be applied for situations where a numeric target is developed to interpret a narrative standard and the numeric value is based on an in-stream concentration of the pollutant of concern.

For some narrative standards such as those relating to sediment, there is often a suite of targets based on stream substrate conditions and other similar indicators. In many of these situations, it is difficult to link the desired target values to highly variable and often episodic in-stream loading conditions. In these situations, the TMDL is often expressed as a percent reduction in total loading based on source quantification results and an evaluation of load reduction potential (**Figure 4-1**). The degree by which existing conditions exceed desired target values can also be used to justify a percent reduction value for a TMDL.

Even if the TMDL is preferably expressed using a time period other than daily, an allowable daily loading rate will also be calculated to meet specific requirements of the Clean Water Act. Where this occurs, TMDL implementation and the development of allocations will still be based on the preferred time period as discussed above.

4.4 Determining Allocations

Once the loading capacity (i.e. TMDL) is determined, that total must be divided, or allocated, among the contributing sources. In addition to basic technical and environmental considerations, this step introduces economic, social, and political considerations. The allocations are often determined by quantifying feasible and achievable load reductions associated with the application of reasonable land, soil, and water conservation practices. Reasonable land, soil, and water conservation practices generally include Best Management Practices (BMPs), but additional conservation practices may be required to achieve compliance with water quality standards and restore beneficial uses. It is important to note that implementation of the TMDL does not conflict with water rights or private property rights. **Figure 4-2** contains a schematic diagram of how TMDLs are allocated to different sources using WLAs for point sources and LAs for natural and nonpoint sources. Although some flexibility in allocations is possible, the sum of all allocations must meet the water quality standards in all segments of the water body.

Under the current regulatory framework for development of TMDLs, flexibility is allowed in the expression of allocations in that *"TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure."* Allocations are typically expressed as a number, a percent reduction (from the current load), or as a surrogate measure, such as a percent increase in canopy density for temperature TMDLs.

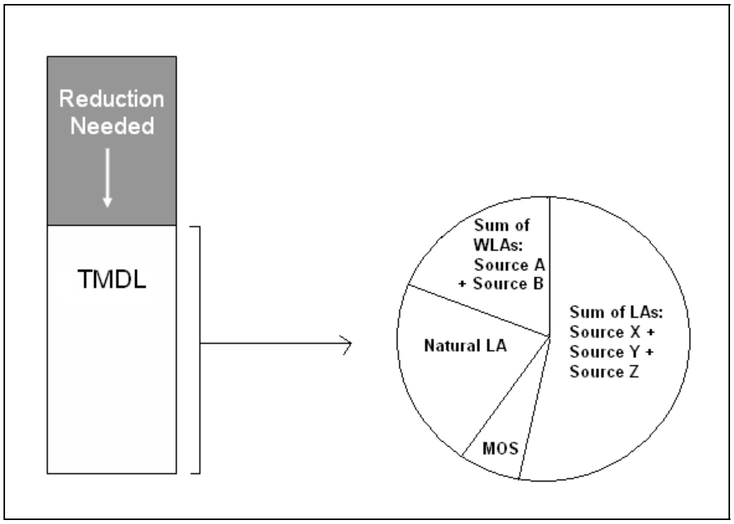


Figure 4-2. Schematic diagram of TMDL and allocations

Incorporating a margin of safety (MOS) is a required component of TMDL development. The MOS accounts for the uncertainty between pollutant loading and water quality and is intended to ensure that load reductions and allocations are sufficient to sustain conditions that will support beneficial uses. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (EPA, 1999).

SECTION 5.0
SEDIMENT TMDL COMPONENTS

This portion of the document focuses on sediment as an identified cause of water quality impairment in the Upper Clark Fork TPA. It describes: 1) the mechanisms by which sediment impair beneficial uses of those streams, 2) the specific stream segments of concern, 3) the presently available data pertaining to sediment impairments in the watershed, 4) the various contributing sources of sediment based on recent data and studies, and 5) the sediment TMDLs and allocations.

The term sediment is used in this document to refer collectively to several closely-related factors associated with the sediment pollutant, including suspended sediment, stream channel geometry that can affect sediment delivery and transport, and sediment deposition on the stream bottom.

5.1 Mechanisms of Effects of Excess Sediment to Beneficial Uses

Sediment is a naturally occurring component of healthy and stable stream and lake ecosystems. Streams in particular are dynamic systems that are dependent on a balance between stream flow and sediment input for their natural function. However, human influence may alter or prohibit the ability of a stream to achieve equilibrium between flow and sediment, which in turn may lead to detrimental effects to the proper form and function of the stream, and may change habitat and water quality conditions.

Erosion and sediment transport and deposition are a function of the natural balance between flow and sediment. Regular flooding allows sediment deposition to build floodplain soils and prevents excess scour of the stream channel. Riparian vegetation and natural instream barriers such as large woody debris, beaver dams, or overhanging vegetation help trap sediment and build channel and floodplain features. When these barriers are absent or excessive erosion is taking place due to altered channel morphology or reduced riparian vegetation, excess sediment is transported through the channel and may be deposited in critical aquatic habitat areas not naturally characterized by high levels of fine sediment.

Increased sediment beyond what is typically present in a naturally occurring condition often has detrimental effects on streams and the aquatic communities living within them. High suspended sediment levels reduce light penetration, which may cause a decline in primary production. As a result, aquatic invertebrate communities may also decline, which may then cause a decline in fish populations. Deposited particles may also obscure sources of food, habitat, hiding places, and nesting sites for invertebrates.

Excess sediment may also impair biological processes of individual aquatic organisms. When present in high levels, sediment may clog the gills of fish and cause other abrasive damage. Abrasion of gill tissues triggers excess mucous secretion, decreased resistance to disease, and a reduction or complete cessation of feeding (Wilber 1983; McCabe and Sandretto 1985; Newcombe and MacDonald 1991). High levels of benthic fine sediment can also impair reproductive success of fish. Fine sediment deposition reduces availability of suitable spawning habitat for salmonid fishes and can smother eggs or hatchlings. An accumulation of benthic fine sediment reduces the flow of water through gravels harboring salmonid eggs, hindering emergence of newly hatched fish, depleting oxygen supply to embryos, and causing metabolic wastes to accumulate around embryos, resulting in higher mortality rates (Armour et al., 1991).

As described in **Section 3.3.2**, sediment as a pollutant is addressed via narrative criteria that do not allow for harmful or other undesirable conditions related to increases in sediment above naturally occurring levels. This is interpreted to mean that water quality goals should strive toward a reference condition that reflects a water body's greatest potential for water quality given current and historic land use activities where all reasonable land, soil, and water conservation practices have been applied and resulting conditions are not harmful, detrimental or injurious to beneficial uses.

5.2 Stream Segments of Concern

The **Table 5-1** presents streams and stream segments that have been listed for sediment impairment on the 2008 303(d) List.

Table 5-1. Water body segments in the Upper Clark Fork TPA with sediment related pollutant and pollution listings on the 2008 303(d) List

Water Body ID	Stream Segment	2008 Probable Causes of Impairment
MT76G005_100	**BROCK CREEK**, headwaters to the mouth (Clark Fork River)	**Sedimentation/siltation**
MT76G002_030	**CABLE CREEK**, headwaters to the mouth (Warm Springs Creek)	**Sedimentation/siltation**, *Other anthropogenic substrate alterations, Physical substrate habitat alterations*
MT76G002_100	**DEMPSEY CREEK**, the national forest boundary to mouth (Clark Fork River)	**Sedimentation/siltation**, *Alteration in stream-side or littoral vegetative covers, low flow alterations*
MT76G005_081	**HOOVER CREEK**, headwaters to Miller Lake	**Sedimentation/siltation**, **Turbidity**
MT76G002_131	**PETERSON CREEK**, headwaters to Jack Creek	**Sedimentation/siltation**, *Alteration in stream-side or littoral vegetative covers*
MT76G002_040	**STORM LAKE CREEK**, headwaters to the mouth (Warm Springs Creek)	**Sedimentation/siltation**, *Alteration in stream-side or littoral vegetative covers*
MT76G005_111	**WARM SPRINGS CREEK**, (near Phosphate), headwaters to line between R9W and R10W	**Sedimentation/siltation**, *Alteration in stream-side or littoral vegetative covers*
MT76G005_112	**WARM SPRINGS CREEK**, (near Phosphate), from line between R9W and R10W to mouth (Clark Fork River)	**Sedimentation/siltation**, *Alteration in stream-side or littoral vegetative covers, Physical substrate habitat alterations*
MT76G002_061	**WILLOW CREEK**, Headwaters to T4N, R10W, Sec 30 (DABC)	**Sedimentation/siltation**, *Alteration in stream-side or littoral vegetative covers*

Pollution listings are presented in *italics*

At the time of the 2007 field investigation, additional Upper Clark Fork TPA streams were included for data collection and analysis as a result of their appearance on earlier 303(d) Impaired waters Lists or due to pollution listings that are often frequently associated with sediment. (Data from the 2007 field effort is presented in **Appendix D** and identified all streams reviewed as part of that study). Sufficient resources and a strong collaborative effort with the Deer Lodge Conservation District (DLCD) and the Watershed Restoration Coalition of the Upper Clark Fork (WRC) allowed for this additional investigation beyond sediment pollutant listed streams. This inclusion of sites from many different streams within the Upper Clark Fork TPA helped provide the foundation for target development, and give a broader representation of sediment issues in both listed and non-listed streams with impaired reaches and "reference" reaches. In some cases, data collected from non-sediment listed streams clearly illustrated a significant impact from sediment. In cases when strong evidence supports developing a TMDL, those streams will be included in the TMDL development and analysis. Non sediment-listed streams included in this report for sediment TMDLs are listed in **Table 5-2**.

Table 5-2. Additional water body segments in the Upper Clark Fork TPA included for TMDL development

Water Body ID	Stream Segment	2006 Probable Causes of Impairment
MT76G002_140	**ANTELOPE CREEK,** headwaters to the mouth (Garnder Ditch)	*Low flow alterations*
MT76G005_082	**HOOVER CREEK**, Miller Lake to the mouth (Clark Fork River)	*Physical substrate habitat alterations*
MT76G002_132	**PETERSON CREEK,** Jack Creek to the mouth (Clark Fork River)	*Alteration in stream-side or littoral vegetative covers, physical substrate habitat alterations*
MT76G005_110	**TIN CUP JOE CREEK**, Tin Cup Lake to the mouth (Clark Fork River)	*Low flow alterations*
MT76G002_062	**WILLOW CREEK**, T4N, R10W, Sec 30 (DABC) to the mouth (Silver Bow Creek)	*Alteration in stream-side or littoral vegetative covers*

Pollution listings are presented in *italics*

5.3 Information Sources and Assessment Methods

Existing data specifically related to sediment conditions for listed tributaries is relatively sparse in the Upper Clark Fork. Where data may exist, varying methods in data collection between agencies and across the watershed, as well as qualitative assessment rather than quantitative data, make sediment impacts difficult to define and compare throughout the planning area. The two main information sources used to assess sediment and habitat conditions for the Clark Fork tributaries of interest are from the DEQ 2007 field effort, and 2007 and 2008 reports produced by the Montana Natural Resource Damage Program and Montana Fish Wildlife and Parks. Additionally, and where available and applicable, data from land management agencies such as the US Forest Service, US Natural Resource & Conservation Service, Deer Lodge Conservation District, and various reports related to the upper Clark Fork and its tributaries, along with field notes, "windshield surveys" from DEQ personnel, and information contained within DEQ Sufficient Credible Data/Beneficial Use Determination (SCD/BUD) files were used to supplement the two main sources of data.

5.3.1 DEQ Longitudinal Field Method for Sediment and Habitat Impairment

In the summer of 2007, 25 sites on listed and non-listed streams throughout the Upper Clark Fork TPA were selected for sediment and habitat data collection. (**Appendix A**, **Figure 20**) Initially, all streams of interest underwent an aerial assessment procedure by which reaches were characterized by four main attributes: stream order, valley gradient, valley confinement, and ecoregion. These four categories represent the main factors that are not influenced by the presence of human activity, and thereby allow for comparisons among those reaches of the same characteristics. However land management practices as a result of the presence of man may have an impact on the way a stream responds, and because of this, reaches were stratified further based on anthropogenic influence, to allow for the observance of natural versus anthropogenic effects. Reaches were then chosen for assessment to allow for a representation of various reach characteristics and anthropogenic influence.

Sediment and habitat related information that was collected includes: width/depth ratio, entrenchment ratio, riffle cross section, riffle pebble count, riffle grid toss, grid toss in pool tails, pool frequency, residual pool depth, riparian green line, and eroding bank analysis. Detailed methodology and procedure for field methods can be found in (DEQ 2009) and data from the field effort is presented in **Appendix D**.

5.3.2 Montana Fish, Wildlife and Parks/Natural Resource Damage Program: An Assessment of Fish Populations and Riparian Habitat in Tributaries of the Upper Clark Fork River Basin

In 2007 and continuing through 2008, FWP and NRDP began a joint effort to assess streams in the Upper Clark Fork River Basin for the purpose of prioritizing stream and fishery restoration needs that are “1) focused in areas that will provide the most benefit to the target fisheries of Silver Bow Creek and the Upper Clark Fork River; and 2) focused on addressing factors that currently limit fish populations.” This effort was largely spurred by a need to prioritize funding of restoration efforts in the basin. Litigation between Atlantic Richfield Co and the State of Montana awarded the State with “a substantial monetary settlement aimed at remediation and restoration of fisheries resources in the UCFRB”. (FWP 2008)

“In addition to fishery data, riparian and fish habitat assessment data were collected. This data was collected to document current habitat conditions at locations where fish were sampled, as well as to highlight potential habitat deficiencies at these sites. This effort, however, was not aimed at identifying all potential impacts to riparian and fish habitat in the sample drainages, and was limited in its spatial and temporal scope.” (FWP 2008) The FWP employed the United States Department of Agriculture – Natural Resource Conservation Service’s Riparian Assessment Worksheet. This information is based on qualitative analysis and best professional judgment of existing conditions. Results of the assessment are tallied and an overall score is determined of Sustainable (>80%), At Risk (50-80%), or Not Sustainable (<50%). These ratings serve as a benchmark for analysis of overall stream condition and were not developed to provide direct interpretation of Montana state water quality standards. However, this information provides good qualitative supplemental information to the DEQ 2007 field effort, and allows for additional linkage to the analysis of aquatic life and fishery beneficial uses within this document.

5.4 Water Quality Targets

5.4.1 Targets

In order to ascertain the relative impact of sediment on a stream and its beneficial uses, comparison of stream conditions to a suite of numeric water quality targets is used. In this case, not one single water quality target is sufficient for determining the condition of a stream, however, when viewed in combination measures of in-stream siltation, morphological characteristics that contribute to loading, storage, and transport of sediment or that demonstrate those effects, and biological response to increased sediment provide a good representation of current condition as it relates to sediment.

In developing these targets, consideration must be made to account for natural variation throughout the river continuum. Specifically, some reaches will have a natural tendency for storage of sediment and others will be more efficient at sediment transport. Therefore, targets follow stratifications employed in the data analysis, such that they can be applied appropriately.

The water quality targets presented in this section (**Table 5-3**) are based on the best available science and information available at the time this document was written. However, targets will be addressed during future TMDL reviews for their validity and may be modified when new information provides a better understanding of reference conditions. Furthermore, the exceedence of one or more target values does not definitively equate to a state of impairment. The degree to which one or more targets are exceeded should be taken into account, and the combination of target analysis, qualitative observations, and sound, scientific professional judgment is crucial when assessing stream condition. A brief description and justification of the target parameters used in the analysis is included in the sections that follow, and rationale and development of target values is included in **Appendix B**.

Table 5-3. Upper Clark Fork TPA Sediment and Habitat Targets

Sediment and Habitat Water Quality Target	**High Gradient Reaches (>2% slope, including Rosgen A and Bstream types)**	**Low Gradient Reaches (<2% slope, including Rosgen C and E stream types)**
Morphology		
Width/Depth Ratio	≤15	≥12 - ≤22
Entrenchment	1.4 - 2.2	≥2.2
Substrate Composition		
Pebble Count, % <2mm	≤7	≤10
Pebble Count, % <6mm	≤18	≤23
Pool Habitat		
Residual Pool Depth (feet)	≥0.8	≥1.0
Pool Frequency (per 1000 feet of stream)	≥15	≥12

5.4.1.1 Morphology

Parameters related to stream morphology describe channel shape and dimension, and thereby indicate the ability of the stream to store and transport sediment. Stream gradient and valley confinement are two significant controlling factors that determine stream form and function, however alterations to the landscape, and sediment input beyond naturally occurring amounts can affect stream morphology. Numerous scientific studies have found trends and common relationships between channel dimensions in properly functioning stream systems. Two of those relationships are used as targets in the Upper Clark Fork TPA and are described below.

Width Depth Ratio
Width/depth ratio is defined as the channel width at bankfull height divided by the mean bankfull depth (Rosgen, 1996). Bankfull is a concept used by hydrologists to define a regularly occurring channel-forming high flow. One of the first generally accepted definitions of bankfull was provided by Dunne and Leopold in 1978:

> *"The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels"*

Width/depth ratio is one of several standard measurements used to classify stream channels (Rosgen, 1996), making it a useful variable for comparing conditions on reaches within the same stream type. Comparison of observed and expected width/depth ratio is a useful indicator of channel overwidening and aggradation, which are often linked to excess streambank erosion or acute or chronic erosion from sources upstream of the study reach. Higher width/depth ratios than those expected indicate streams that may not be properly functioning or have higher sediment loads. Channels that are overwidened often are associated with excess sediment deposition and streambank erosion, contain shallower, warmer water, and provide fewer deepwater habitat refugia for fish.

Entrenchment Ratio
Stream entrenchment ratio is equal to the floodprone width divided by the bankfull width (Rosgen, 1996). Entrenchment ratio is used to help determine if a stream shows departure from its natural stream type. It is an indicator of stream incisement, and therefore indicates how easily a stream can access its floodplain. Streams are often incised due to detrimental land management or may be naturally incised due to landscape characteristics. A stream that is overly entrenched (entrenchment ratio <1.4) generally is more prone to streambank erosion due to greater energy exerted on the banks during high flow periods. Greater scouring energy in incised channels results in higher sediment loads derived from eroding banks. If the stream is not actively degrading (downcutting), the sources of human caused incisement are historic in nature and may not currently be present, although sediment loading may continue to occur. Entrenchment ratio is an important measure of channel condition as it relates to sediment loading and habitat condition, due to the long-lasting impacts of incisement and large potential for sediment loading in incised channels.

5.4.1.2 Substrate Composition

Percent surface fines provide a good measure of the siltation occurring in a river system and serve as an indicator of stream bottom aquatic habitat and its ability to support aquatic life. Although it is difficult to correlate percent surface fines with loading in mass per time directly, the Clean Water Act allows “other applicable measures” for the development of TMDL water quality restoration plans. Percent surface fines have been used successfully in other TMDLs in western Montana addressing sediment related to stream bottom deposits, siltation, and aquatic life uses.

Percent Fines <2mm
Surface fine sediment measured in the Wolman (1954) pebble count is one indicator of aquatic habitat condition and can indicate excessive sediment loading. Studies have shown that increased substrate fine materials less than 2mm can adversely affect embryo development success by limiting the amount of oxygen needed for development (Meehan 1991). As well, the TMDL for the Flathead Headwaters (DEQ 2004) cites recent work completed in the Boise National Forest in Idaho, which showed a strong correlation between the health of macroinvertebrate communities and percent surface fines defined as all particles less than two millimeters.

Percent Fines <6mm
As with surface fine sediment smaller than 2mm diameter, an accumulation of surface fine sediment less than 6mm diameter may indicate excess sedimentation. The size distribution of substrate material in the streambed is also indicative of habitat quality for salmonid spawning and incubation. Excess surface fine substrate smaller than 6.35 mm may have detrimental impacts on aquatic habitat. Weaver and Fraley (1991) observed a significant inverse relationship between the percentage of material less than 6.35 mm and the emergence success of westslope cutthroat trout and bull trout.

5.4.1.3 Pool Features

Pools are morphological features that are characterized by slow moving, deep sections of the stream. These important components aid in the balance between flow and sediment load by reducing stream velocity and storing water and sediment. Pool features also play an important role for the aquatic life and fisheries by providing refuge from warm water, high velocity, and terrestrial predators. However, when sediment loads are excessive, pool habitat quality and frequency is often diminished as pools fill with sediment. As this happens, velocities increase, stream channels widen, and sediment is transported to other areas of the stream where it is sometimes deposited in areas that have an additional impact on fisheries and aquatic life. The measure and comparison of pool features can have direct links to sediment load increases and its affect on stream form and function, as well as biological integrity.

Residual Pool Depth
Residual pool depth, defined as the difference between pool maximum depth and crest depth, (end of the pool depth), is a discharge-independent measure of pool depth and an indicator of the quality of pool habitat. Essentially it represents the depth of water that would remain in a pool if

water ceased to flow through the channel, and only the where pools occur remained filled. Deep pools are important resting and hiding habitat for fish, and provide refuge during temperature extremes and high flow periods. Pool residual depth is also an indirect measurement of sediment inputs to listed streams. An increase in sediment loading would be expected to cause pools to fill, thus decreasing residual pool depth over time.

Pool Frequency
Pool frequency is a measure of the availability of pool habitat to provide rearing habitat, cover, and refuge for fish. Pool frequency is related to channel complexity, availability of stable obstacles, and sediment supply. Excessive erosion and sediment deposition can reduce pool frequency by filling in smaller pools. Pool frequency can also be affected adversely by riparian habitat degradation resulting in a reduced supply of large woody debris or scouring from stable root masses in streambanks.

5.4.2 Supporting Information/Supplemental Water Quality Parameters

Although the following categories are not a direct measure of sediment, they do provide insight into the condition of the stream and streambanks or of the overall riparian quality which often is associated with factors that may be leading to increased sediment loads and the reduction of habitat.

Understory Shrub Cover along Green Line
Riparian shrub cover is one of the most important influences on streambank stability. Removal of riparian shrub cover can dramatically increase streambank erosion and increase channel width/depth ratios. Shrubs stabilize streambanks by holding soil and armoring lower banks with their roots, and reduce scouring energy of water by slowing flows with their branches.

Good riparian shrub cover is also important for fish habitat. Riparian shrubs provide shade, reducing solar inputs and increases in water temperature. The dense network of fibrous roots of riparian shrubs allows streambanks to remain intact while water scours the lowest portion of streambanks, creating important fish habitat in the form of overhanging banks and lateral scour pools. Overhanging branches of riparian shrubs provide important cover for aquatic species. In addition, riparian shrubs provide critical inputs of food for fish and their feed species. Terrestrial insects falling from riparian shrubs provide one main food source for fish. Organic inputs from shrubs, such as leaves and small twigs, provide food for aquatic macroinvertebrates, which are an important food source for fish.

Based on a general review of riparian shrub cover results from Greenline studies conducted during the 2007 DEQ field efforts, a goal of 70% or greater shrub cover should be considered under most conditions for streams in the Upper Clark Fork watershed.

Bare ground along Green Line
Percent bare ground is an important indicator of erosion potential, as well as an indicator of land management influences on riparian habitat. Bare ground was noted in the greenline inventory in cases where recent ground disturbance was observed, leaving bare soil exposed. Bare ground is often caused by trampling from livestock or wildlife, fallen trees, recent bank failure, new

sediment deposits from overland or overbank flow, or severe disturbance in the riparian area, such as from past mining, road-building, or fire. Ground cover on streambanks is important to prevent sediment recruitment to stream channels. Sediment can wash in from unprotected areas due to snowmelt, storm runoff, or flooding. Bare areas are also much more susceptible to erosion from hoof shear. Most stream reaches have a small amount of naturally-occurring bare ground. As conditions are highly variable, this measurement is most useful when compared to reference values from best available conditions within the study area or literature values.

Based on a general review of riparian shrub cover results from Greenline studies conducted during the 2007 DEQ field efforts, a goal of 5% or less bare ground should be considered under most conditions for streams in the Upper Clark Fork watershed.

5.4.5 Comparison of Listed Waters to Targets (by stream segment)

5.4.5.1 Brock Creek, headwaters to the mouth (MT76G005_100)

Comparison of results from the 2007 field data collection show high percent fines for both categories of substrate size. Morphological characteristics are within the target range, and pool habitat is appropriate in regards to frequency, however residual pool depth is slightly below the target indicating marginal pool depths. Percent shrub cover is below what would be expected for this stream and percent bare ground is high (**Table 5-4**).

Results of the FWP stream assessments at two locations on Brock Creek show the site at RM 7.8 categorized as “sustainable”, however RM 4.4, which occurs near the same site as the BRK-19 is rated as “at risk” (**Table 5-5**).

Table 5-4. 2007 DEQ Sediment and Habitat Field Study – Selected Data for Brock Creek

		Morphology		**Substrate Composition**		**Pool Habitat**		**Greenline**	
Site	**Gradient Category**	**W/D Ratio**	**Entrnch. Ratio**	**<2mm**	**<6mm**	**Residual Pool Depth**	**Pool Frequency**	**Percent Shrub Cover**	**Percent Bare Ground**
BRK-19	High	11.8	2.0	**18**	**33**	**0.7**	26	63	28

Table 5-5. 2007 FWP Stream Assessment Results for Brock Creek

Site Description	**DEQ Reach**	**Gradient Category**	**W/D Ratio**	**Geomorph Rating**	**Veg Rating**	**Fish Rating**	**All Considerations**
RM 4.4	BRK-19	High	8.1	77	73	70	74
RM 7.8	BRK-13	Low	N/A	100	87	100	94

Like many streams in the upper Clark Fork, Brock Creek is located in a watershed with a history of mining. The channel at BRK-19 and RM 4.4 is incised within a gulch that appears to be at least partially formed by historic rail road fill along river right. Wetland vegetation along the channel margin indicates the channel may be recovering from an over-widened state and may be re-establishing a small floodplain at the lower base level. There was some evidence of grazing access points along the reach. There was dense understory shrub cover along this reach, primarily comprised of alders. Extensive weeds were observed on the terraces. Vertical eroding banks with a clay composition were observed along a portion of the reach as well. There were some smaller, shallow pools associated with “alder” woody debris, though pools either lacked spawning habitat or the substrate was too fine. The fine silty sediment in some places caused the water to be murky when wading. There was a high amount of bare ground described in the Greenline assessment along the channel in areas with dense woody vegetation cover, though most of it did not appear to be disturbed by recent impacts, except discrete areas where there were livestock access points. Fish sampling has shown that Brock Creek supports a population of westslope cutthroat trout. This reach appeared to be well representative of the overall condition of lower Brock Creek.

Further upstream the Brock Creek flows through a narrower, timbered canyon with a road paralleling the stream along much of its length. Despite the encroachment of the road, and evidence of recent and past timber harvest, the stream appeared stable and little active erosion was evident. Some noxious weeds and undesirable plants were present in the area, but most were associated with the road disturbance zone. (FWP 2009).

Brock Creek morphology and pool habitat do not appear to be far from the desired condition, however high percent fines in riffles coupled with marginal riparian condition, particularly in the lower sections of the stream identify Brock Creek as in need of continued improvement in order to maintain support for fisheries and aquatic life. A TMDL will be developed for Brock Creek.

5.4.5.2 Cable Creek, headwaters to the mouth (MT76G002_030)

Cable Creek was not included in the DEQ 2007 field data collection effort; however aerial assessment, habitat data from the USFS Pintler Ranger District, a windshield survey of the watershed, and data from the DEQ SCD/BUD files were reviewed. Percent fine information for those mainstem reaches on Cable Creek (Reaches 1-3) show significantly fine sediment composition in Reaches 1 and 2. Pool depth in Reach 3 is within the range for a high gradient reach, but the bank stability rating and % eroding bank indicate sediment contributions here. (**Table 5-6**). Substrate composition in Reaches 4-6 are high but not necessarily indicative of problems since they are small, spring fed, and intermittent.

Table 5-6. USFS – Pintler Ranger District; May 28, 1997 Cable Creek Stream Walkthrough – Selected Data

	Substrate Composition		**Pool Habitat**	**Riparian and Streambank Condition**	
	<2 mm	**2-8mm**	**Avg Pool depth**	**Bank Stability**	**% Eroding Bank**
Reach 1	-	5	1.3	95	5
Reach 2	**30**	**60**	1.5	95	5
Reach 3	**35**	**5**	0.8	75	25
Reach 4	**100**	-	0.2	100	0
Reach 5	**20**	**26**	0.4	95	5
Reach 6	**10**	**20**	0.4	n/a	n/a

Below are descriptions of the USFS Cable Creek reaches:

- Reaches 4, 5, and 6 are small side tributaries that originate from springs and contain intermittent flow.
- Reach 1 is located near the Spring Hill Picnic Area. This is a higher gradient section of stream (6% average) and therefore less deposition of fine sediment would be expected here. Streambank stability was noted to be good and surrounding uses seem to have limited impact on the sediment input to the stream.
- Reach 2 is described as a Rosgen E4 channel which are noted as "channel systems with low to moderate sinuosity, gentle to moderately steep channel gradients, with very low channel width/depth ratios." (Rosgen, 1996) High percentages of small substrate classes in Reach 2 exist, however this may in part be a result of a downstream beaver dam complex which may also contribute to the depositional nature of this reach and the resulting high fines.
- Reach 3 is characterized as a Rosgen B4 channel which is typically described as "moderately entrenched systems on gradients of 2-4%." "The B4 stream type is considered relatively stable and is not a high sediment supply stream channel." (Rosgen, 1996) Reach 3 however has a streambank stability rating of 75% as opposed to the 95% from the other reaches surveyed by the USFS. This reach also occurs in the proximity of the Cable Mountain Mine. From the field form comments, "Mining disturbance very evident – many test dig[s] into banks on floodplain." Mining impacts were noted along 70% of the reach, with silt, and channelized stream noted as the type of impact. High percent fines in this reach are uncharacteristic of a B4 stream channel and are likely the result of the mining impacts from this area.

In this subwatershed, sediment from roads that parallel much of Cable Creek and specifically the area around Cable Mine appear to be the significant sources for sediment as noted in the DEQ SCD/BUD files, the USFS Reach description above, and as witnessed during the windshield survey. Although data collected by the USFS does not exactly conform to all water quality target parameters, comparison to Upper Clark Fork TPA desired conditions and evaluation of the stream is possible based on this and other available data. Based on the information from the USFS and other sources as mentioned above, a TMDL will be developed for Cable Creek.

5.4.5.3 Dempsey Creek, the national forest boundary to the mouth (MT76G002_100)

Table 5-7. 2007 FWP Stream Assessment Results for Dempsey Creek

Site Description	DEQ Reach	Gradient Category	W/D Ratio	Geomorph Rating	Veg Rating	Fish Rating	All Considerations
RM 4.4	DMP-28	High	7.9	87	33	43	58
RM 5.0	DMP-26	High	8.6	77	70	70	74

Due to limited access on private land, Dempsey Creek was not included in the DEQ 2007 field data collection effort; however qualitative information summaries from the DEQ SCD/BUD file describe areas of severe impairment [from grazing practices] occurring in clusters from the mouth through the first 2-4 miles of stream. Aerial photo analysis and a windshield survey through the Dempsey Creek watershed support this description and this degraded condition is also reflected in the FWP assessments at RM 4.4 and 5.0 (**Table 5-7**), which both rate "at risk". The individual vegetation rating and fish habitat rating for RM 4.4 were low at 33 and 43, respectively. A TMDL will be developed for Dempsey Creek.

5.4.5.4 Hoover Creek, headwaters to Miller Lake (MT76G005_081)

Comparison of results from the 2007 field data collection show percent fines slightly above target values for both categories of substrate size. A lower entrenchment ratio would be expected for a higher gradient reach but this site may exhibit a discrete area that is transitioning through a lower gradient section of the reach and is therefore less entrenched. Pool habitat is expected in regards to frequency, however residual pool depth is below the target values and is marginal. Percent shrub cover is also below what would be expected for this stream (**Table 5-8**). All Considerations rate as "sustainable" for two sites assessed by FWP, however the fish habitat ratings at RM 9.7 was somewhat low **(Table 5-9)**.

Table 5-8. 2007 DEQ Sediment and Habitat Field Study – Selected Data for Hoover Creek

		Morphology		**Substrate Composition**		**Pool Habitat**		**Greenline**	
Site	**Gradient Category**	**W/D Ratio**	**Entrnch. Ratio**	**<2mm**	**<6mm**	**Residual Pool Depth**	**Pool Frequency**	**Percent Shrub Cover**	**Percent Bare Ground**
HVR-07	High	14.8	**3.3**	**11**	**26**	**0.5**	20	62	1

Table 5-9. 2007 FWP Stream Assessment Results for Hoover Creek

Site Description	**DEQ Reach**	**Gradient Category**	**W/D Ratio**	**Geomorph Rating**	**Veg Rating**	**Fish Rating**	**All Considerations**
RM 7.0	HVR-07	High	7.9	100	87	70	90
RM 9.7	HVR-05	High	8.0	100	85	43	87

HVR-07 is located upstream of Miller Lake in an area that appeared to at one time have intensive timber harvest and also shows signs of recent grazing. The creek, where accessible, appeared to be somewhat entrenched and was migrating into the terrace in some places, resulting in some eroding banks. The reason the stream was entrenched was unclear, though increases in water yield due to historic timber harvest or management of the downstream reservoir are potential causes. Signs of disturbance in this reach were evident; there were extensive invasive weeds in the field to river right, and the hillslope adjacent to river left had been previously logged. However, wetland vegetation along the channel margin suggests the stream is recovering from an over-widened condition, and younger alders along the channel margin and aspen on the terraces also suggest recovery. This reach contains a meandering channel with pools at meander bends and some undercut banks. The substrate is slightly high in percent fines.

Summary descriptions from two sites assessed by the FWP on upper Hoover Creek are somewhat similar to the DEQ narrative description: "The channel had access to a small floodplain and appeared vertically as well as laterally stable. Additionally, past beaver activity was also noted in and around the survey reach. Woody riparian vegetation was comprised mainly of alder, willow, and conifer trees. However, woody plants were patchy in the riparian zone, and openings dominated by grasses and sedges were common. Disturbance-induced plants, including Canada thistle, were also present in the riparian area, but most were not overly dense. Widespread timber harvest was evident to the south of the channel on the adjacent hillside. Fish habitat at RM 7.0 was rated as good (score: 7 points out of a potential of 10), but was slightly limited by a general lack of woody debris and rootwads in the channel. Also, the patchiness of woody shrubs and trees along the stream left segments lacking significant overhead cover and shade." (FWP 2009)

Also from the 2009 FWP report: "Near the upper extent of the drainage at RM 9.7, Hoover Creek was flowing through a narrow, conifer covered canyon, and was more representative of a Rosgen B stream type. The total riparian assessment score was 55 out of a potential score of 63 (87%). The riparian canopy was comprised primarily of spruce and alder, which provided a reasonable amount of shade and cover to the channel. Channel stability was good and no excessive erosion was noted. The area was immediately adjacent to a well-traveled forest road and some disturbance-induced plants (primarily bull thistle and common mullen) and noxious weeds (houndstounge and tall buttercup) were noted throughout the narrow riparian zone. Livestock presence was also evident, and browse pressure on palatable woody plants was moderate. Fish habitat in this segment of Hoover Creek was rated as fair (score: 3 points out of a potential of 7), and was limited by a lack of deep pools. Fine sediment accumulation was notable and was likely correlated with the forest road network in the upper watershed. Culverts at two road crossings above and below (RM 9.8 and 9.4, respectively) the survey section were examined, and neither was very conducive to fish or debris passage. The lower culvert (RM 9.4) had debris buildup at the inlet, and the outlet of the upper culvert (RM 9.8) was slightly perched."

The listed segment of Hoover Creek was listed as impaired for the Primary Contact Recreation designated use. No other beneficial uses had been assessed to date. Sediment and habitat data collected as part of the 2007 field effort focuses mainly on the impact on aquatic life and fisheries. Based on the target comparison, and the observed potential sources that exist in this reach a TMDL will be developed for the upper segment of Hoover Creek.

5.4.5.5 Peterson Creek, headwaters to Jack Creek (MT76G002_131)

Access to appropriate sample reaches in the upper segment of Peterson Creek was limited and no sampling sites were conducted during the 2007 field effort. Much of upper Peterson Creek is influenced by beaver activity, and the backwater conditions, and multiple meandering threads through willow dominated riparian areas did not allow for the application of the stream assessment methodology used in that effort. However, an earlier study conducted by KirK Environmental (KirK 2003) for the Watershed Restoration Coalition of the Upper Clark Fork (WRC) and the 2009 FWP report do provide some information about this stream segment.

Comparison of results from the KirK report show percent fines well above target values for both categories of substrate size. Morphology results also show a high degree of entrenchment, particularly at site P-6 (**Table 5-10**). Pool information and greenline data was not collected (**Table 5-11**).

The 2003 KirK environmental report notes that in the upper segment of Peterson Creek, "the stream corridor varies in condition, and beavers are well established as part of the stream corridor and ecology." Additionally, "Grazing and watering along some reaches of upper Peterson Creek have resulted in loss of some riparian vegetation and morphological changes in the stream channel, such as widening of the stream channel."

Table 5-10. 2004 East Valley Watershed Report – Selected Data for Peterson Creek

		Morphology		**Substrate Composition**		**Pool Habitat**		**Greenline**	
Site	**Gradient Category**	**W/D Ratio**	**Entrnch. Ratio**	**<2mm**	**<6mm**	**Residual Pool Depth**	**Pool Frequency**	**Percent Shrub Cover**	**Percent Bare Ground**
P-5	High	11.8	**2.3**	**38**	**54**	n/a	n/a	n/a	n/a
P-6	High	7.1	**1.2**	**32**	**35**	n/a	n/a	n/a	n/a

Table 5-11. 2007 FWP Stream Assessment Results for Peterson Creek

Site Description	**DEQ Reach**	**Gradient Category**	**W/D Ratio**	**Geomorph Rating**	**Veg Rating**	**Fish Rating**	**All Considerations**
RM 7.9	PTR-09	Low	10.2	70	71	43	67
RM 11.5	PTR-04	Low	5.0	100	83	43	87

FWP also included two sites in upper Peterson Creek. Those sites were rated as "Sustainable" for site RM 11.5, and "At Risk" at RM 7.9. Those results and the descriptions follow:

At RM 7.9, Peterson Creek was flowing through a deep, timbered canyon, with an extremely limited floodplain. The stream was classified as a Rosgen B channel type, and the total riparian assessment score was 39 out of a potential score of 58 (67%). There was evidence of old mining activity in the reach, and several bank failures and areas of erosion were noted. Douglas fir and a few mature cottonwood trees provided most of the woody riparian canopy, although sparse alder plants were also present along the channel. Fish habitat at RM 7.9 was rated only fair (score: 3 points out of a potential of 7), and was most limited by low flow, and a lack of deep pools. Much of the available habitat was shallow riffles and pocket water. A sizeable irrigation diversion was located upstream of the sample site at RM 10.0. (FWP 2009)

At RM 11.5, Peterson Creek was classified as a Rosgen B channel type. The survey reach was situated just upstream of an almost two mile long segment that was dominated by extensive beaver activity. Numerous ponds and dense willows were present throughout this downstream area. Within the survey reach, the channel was relatively stable and the total riparian assessment score was 58 out of a potential score of 67 (87%). Woody riparian vegetation was comprised of willow, alder, spruce, and aspen. A few disturbance-induced openings were present in the riparian canopy, and were likely related historic placer mining activity and current livestock use. Fish habitat at RM 11.5 was rated only fair (score: 3 points out of a potential of 7), and was most limited by a lack of deep, quality pools. Much of the available habitat was comprised of shallow pocket water. A road crossing was present immediately below the electrofishing reach, and the culvert appeared to be a partial barrier to fish moving upstream. The outlet of the pipe was slightly perched, and the inlet had a fair amount of debris buildup on it. (FWP 2009)

As a result of the high fines, entrenchment, and reduced habitat ratings (particularly at RM 7.9) a TMDL will be developed for upper Peterson Creek. It should be noted however that focus on meeting the TMDL should be related to the anthropogenic activities in upper Peterson Creek such as the grazing and watering, and roads/road crossings that influence this segment, and that the impacts to habitat and stream morphology from beaver would be considered naturally occurring conditions that would not be expected to change in order to meet the TMDL.

5.4.5.6 Storm Lake Creek, headwaters to the mouth (MT76G002_040)

Due to the fact that Storm Lake was assessed in 2004 by EPA it was not included in the 2007 DEQ field effort. Data from the 2004 site visit was used for the original assessment determination and is included in **Table 5-12**. While no pool habitat data and greenline results were collected, substrate composition clearly exceeds targets. Additionally, some anthropogenic influences were noted; obvious signs of logging, a road that parallels the stream for much of its length, and the channelization and re-routing of the lower portion of the stream.

The FWP report also identifies RM 0.6 as “At Risk”, and Fish Habitat ratings in the lower two FWP sites was also limited (**Table 5-13**). A TMDL will be developed for Storm Lake Creek.

Table 5-12. 2004 EPA Sediment and Habitat Field Study – Selected Data for Storm Lake Creek

		Morphology		**Substrate Composition**		**Pool Habitat**		**Greenline**	
Site	**Gradient Category**	**W/D Ratio**	**Entrnch. Ratio**	**<2mm**	**<6mm**	**Residual Pool Depth**	**Pool Frequency**	**Percent Shrub Cover**	**Percent Bare Ground**
Upper	High	13.5	**3.0**	**27**	**52**	n/a	n/a	n/a	n/a
Lower	Low	21.6	2.6	**24**	**34**	n/a	n/a	n/a	n/a

Table 5-13. 2007 FWP Stream Assessment Results for Storm Lake Creek

Site Description	**DEQ Reach**	**Gradient Category**	**W/D Ratio**	**Geomorph Rating**	**Veg Rating**	**Fish Rating**	**All Considerations**
RM 0.6	STL-19	High	10.0	73	82	0	66
RM 1.4	STL-17	High	9.0	100	96	30	87
RM 3.0	STL-16	High	9.3	100	100	100	100
RM 4.2	STL-13	High	8.3	100	93	70	93
RM 6.3	STL-08	High	10.4	100	100	100	100

5.4.5.7 Warm Springs Creek, near Phosphate, headwaters to the line between R9W and R10W to mouth (MT76GG005_111)

Results from the 2007 field effort showed no exceedance of morphology and substrate composition targets, and slight exceedance of pool habitat targets (**Table 5-14**). Greenline shrub cover was less than desired although this is largely a result of the effects of the road and canyon confinement in this reach. The FWP rating at a site further upstream was rated “At Risk” although marginally so (**Table 5-15**).

Table 5-14. 2007 DEQ Sediment and Habitat Field Study – Selected Data for Warm Springs Creek

		Morphology		**Substrate Composition**		**Pool Habitat**		**Greenline**	
Site	**Gradient Category**	**W/D Ratio**	**Entrnch. Ratio**	**<2mm**	**<6mm**	**Residual Pool Depth**	**Pool Frequency**	**Percent Shrub Cover**	**Percent Bare Ground**
WSP-21-1	High	11.5	1.5	2	3	0.8	**8**	53	0
WSP21-2	High	9.2	1.8	4	6	**0.7**	20	56	1

Table 5-15. 2007 FWP Stream Assessment Results for Warm Springs Creek

Site Description	**DEQ Reach**	**Gradient Category**	**W/D Ratio**	**Geomorph Rating**	**Veg Rating**	**Fish Rating**	**All Considerations**
RM 11.5	WSP-09	High	6.1	83	73	70	77

Two sites were assessed in Warm Springs during the 2007 DEQ field effort and both were dry during the site visit, though the stream was flowing upstream and downstream of the reach. During runoff, the assessed reach also reportedly had lower streamflow than upstream and downstream reaches (based on conversation with local landowners), suggesting that stream power and sediment transport may be reduced compared to other sections of stream. This reach is in a section where the stream has been channelized to accommodate the road on river right and further confined by the narrow valley through which the stream is flowing. While this reach was likely naturally confined by steep hillslopes, it appeared that the road has increased confinement and simplified the system, leading to a reduction in LWD input and a reduction in pool formation. Riparian vegetation was limited to a narrow band along the channel and included red osier dogwood in the understory on river left, while the vegetation was less dense along the road fill on river right. The reach lacked spawning gravels and fine sediment did not appear to be a problem. In places, the stream has cut into the hillslope and these areas are sources of sediment due to both stream power and hillslope erosion processes. Similarly, exposed road fill on river right is a source of sediment in places, though much of the road fill was comprised of angular cobble “riprap”. Despite this, streambank erosion was limited in this reach due to riparian vegetation along river left as well and the overall small size of the stream.

The 2009 FWP report echoes many of the same conclusions regarding upper Warm Springs Creek: “At RM 11.5, Warm Springs Creek was in a relatively deep canyon with a narrow valley bottom. Stream gradient was fairly low and the channel displayed characteristics of a Rosgen Bc channel type. An infrequently used road that occupied much of the riparian area was situated in the valley bottom near the survey section. The total riparian assessment score was 54 out of a potential score of 70 (77%). While the stream was vertically stable and had access to a small floodplain adjacent to the channel, lateral erosion was evident on outside banks lacking deep-rooted vegetation. Woody riparian vegetation was comprised largely of willow, alder, and lodgepole pine. However, the density of these plants along the stream channel was rather low, and their distribution was patchy. Disturbance-induced grasses were common throughout the riparian zone, and livestock use adjacent to the stream was notable. Fish habitat at RM 11.5 was rated as good, but was less than its potential. While there were several quality pools and undercut banks in the survey reach, the sparse woody shrubs and trees along the streambanks provided relatively little overhead cover and shade. Additionally, woody debris in the channel was mostly absent from the reach. Extensive timber harvest was noted upstream of the survey reach in much of the upper watershed.” (FWP, 2009)

For the most part, data complied with targets. The low shrub cover is largely due to the influence of the parallel road. Restoration potential beyond additional vegetative cover on the road fill is limited by the road and canyon confinement. BMP berms along the road were observed, which should reduce overall road wash load. A TMDL will not be pursued for upper Warm Springs Creek.

5.4.5.8 Warm Springs Creek, near Phosphate, from the line between R9W and R10W to mouth (MT76G005_112)

Results of the 2007 field effort found morphology and substrate composition parameters not meeting targets (**Table 5-16**). Greenline percent shrub cover results was also considerably low. FWP ratings concluded that this reach was “At Risk” (**Table 5-17**).

Table 5-16. 2007 DEQ Sediment and Habitat Field Study – Selected Data for Warm Springs Creek

		Morphology		Substrate Composition		Pool Habitat		Greenline	
Site	**Gradient Category**	**W/D Ratio**	**Entrnch. Ratio**	**<2mm**	**<6mm**	**Residual Pool Depth**	**Pool Frequency**	**Percent Shrub Cover**	**Percent Bare Ground**
WSP-29	Low	**7.7**	**1.5**	**22**	**31**	1.2	18	16	0

Table 5-17. 2007 FWP Stream Assessment Results for Warm Springs Creek

Site Description	DEQ Reach	Gradient Category	W/D Ratio	Geomorph Rating	Veg Rating	Fish Rating	All Considerations
RM 0.6	WSP-29	Low	**10.5**	77	60	70	69

Lower Warm Springs Creek is a spring-fed creek with small particle size substrate and extensive aquatic plant growth that influences channel morphology and provides cover for fish. Growth of aquatic vegetation breaks the surface and forms “pseudo- riffles” in this stream, however many of these areas could potentially be classified as runs. The stream is very sinuous, though slightly entrenched in some places. Several fish (~12”) were observed during the site visit utilizing the undercuts and the aquatic vegetation for cover. There is a narrow riparian buffer with younger willows and some wetland vegetation re-colonizing the channel margin, suggesting the stream may be recovering from an over-widened and entrenched system to an E or C type with a broader floodplain. Beaver complexes may also have some affect in this stream. Nearly vertical eroding banks occurred at the outsides of most meander bends. Retreat rate in this stream may be lower than others however due to the clay bank composition and the semi-stable flows from the constant ground water influence. Those banks with observed denser riparian vegetation were undercut, providing additional cover. Some sections of lower Warm Springs Creek have obvious sign of cattle trampling and livestock access; these areas typically demonstrated the reduced riparian vegetation cover and the more prominent vertical eroding banks.

Again, the 2009 FWP report coincides with many of the observations from the 2007 DEQ study. “At RM 0.6, the stream was situated in relatively wide portion of the valley and was flowing through an irrigated hay meadow. The stream was deep and rather sinuous and was classified as a Rosgen E channel type. The total riparian assessment score was 48 out of a potential score of 70 (69%). The channel was somewhat incised (approximately 3-6 ft), although no active downcutting was noted during the survey. However, several outside banks lacking deep-rooted woody vegetation did show notable erosion. Upstream of the sample site, an old wood retaining wall had been constructed on an outside bend, likely a past effort to control lateral erosion. Riparian vegetation was comprised heavily of hay grasses and disturbance-induced weeds. Willow and alder were also present throughout the reach, but their density was limited and their distribution patchy. Fish habitat at RM 0.6 was rated as good, but was somewhat limited by the lack of cover and shade that would have been afforded by an increased density of woody shrubs along the stream banks. Deep pools however, were common and abundant aquatic vegetation provided fair cover for fish of all sizes. Stream substrate was relatively fine (silt/sand) and areas of spawning gravel were limited and site specific. Below the survey section, the stream flowed through a farmstead and adjacent livestock corrals. At least one irrigation diversion was observed upstream of the sample site.”

Although morphology and pool habitat in lower Warm Springs Creek was within the range of the target values, percent fines exceed targets and percent shrub cover is significantly low. High percent fines are probably a result of eroding banks where riparian conditions are minimal and the observation of these fines may also be attributed to the lowering of stream velocity from the aquatic vegetation. A TMDL will be pursued for lower Warm Springs Creek.

It should be noted that lower Warm Springs Creek is more difficult to assess in terms of sediment and habitat character because of the seemingly good condition of the morphology and pool data from the site measured. Percent fines, while above target values, may also be masked somewhat by the fact that this reach may be transitioning to an E channel which tend to have higher fine percentages; the steady flow ground-water system which may limit flushing capabilities; and the aquatic vegetation which may also be limiting the ability of the stream to transport fines at certain flows. Despite this however, anthropogenic sources and riparian grazing are clearly observed throughout the lower reach and present an obvious source of controllable sediment load.

5.4.5.9 Willow Creek, headwaters to T4N, R10W, Sec 30 (MT76G002_061)

Percent fines did not meet targets for the two sites where data was collected on upper Willow Creek, however all other targets appeared acceptable with exception of width/depth ratios, which were only marginally above the target (**Table 5-18**). FWP also conducted an assessment on upper Willow and found that site to be “Sustainable” (**Table 5-19**).

Table 5-18. 2007 DEQ Sediment and Habitat Field Study – Selected Data for Willow Creek

		Morphology		**Substrate Composition**		**Pool Habitat**		**Greenline**	
Site	**Gradient Category**	**W/D Ratio**	**Entrnch. Ratio**	**<2mm**	**<6mm**	**Residual Pool Depth**	**Pool Frequency**	**Percent Shrub Cover**	**Percent Bare Ground**
WLW-11	High	**16.0**	1.4	**11**	**19**	0.9	23	83	2
EPA-upper	High	**17.8**	1.4	**33**	**38**	n/a	n/a	n/a	n/a
EPA - lower	High	4.6	20.6	-	-	-	-	n/a	n/a

Table 5-19. 2007 FWP Stream Assessment Results for Willow Creek

Site Description	**DEQ Reach**	**Gradient Category**	**W/D Ratio**	**Geomorph Rating**	**Veg Rating**	**Fish Rating**	**All Considerations**
RM 8.4	WLW-10	High	7.4	77	97	70	84

WLW-11 is located on State land in a meadow area. At the time of the assessment, the road on the river left of the floodplain had been recently improved and active logging was occurring in the watershed during the site visit. Recently constructed BMPs along the road did not appear to be effective as sediment loading was witnessed along the road fringe and within the channel. Both the road and the logging activities are likely upland sources of sediment. Floodplain and channel encroachment due to the road was leading to accelerated bank erosion at several sites as the stream cut into the road fill and the terrace. There were numerous pools, often situated at the outside of meander bends with overhanging willows. Willows and red osier dogwood comprised the understory, with some wetland vegetation and weeds.

In addition to the site reviewed by DEQ in 2007, two sites were assessed in 2004 by the EPA on upper Willow Creek. The upper site of the two was classified as a high gradient channel. Riparian vegetation composition appeared good, however some effect to the morphology of the stream was noted, and high fines were present. There were no obvious or apparent current human influences noted for during the EPA assessment however eroding banks were frequently observed.

The lower site assessed by the EPA occurred in an area influenced by a railroad line, grazing, and beaver complexes. Channel form and function has clearly been disturbed through this area as evidenced by the morphology results. Percent fines were not measured as the stream bottom was silt dominated and it was clear that fine sediment was overwhelming substrate material.

The 2009 FWP study also assessed a reach on Willow Creek at river mile 8.4. “There was a fair amount of bank erosion present in the reach, and the channel appeared to have down cut sometime in the past.” Riparian condition as a whole was good, however noxious weeds were apparent in and likely has a connection to the bank erosion that occurs at this site. Also, “Fish habitat at RM 8.4 was rated good, but was somewhat limited by notable fine sediment accumulation.” (FWP, 2009)

Although target values are met in most instances, as a result of high percent fines found from the results of the DEQ and EPA assessments and the clear presence of sources in upper Willow Creek, a TMDL will be developed for upper Willow Creek.

5.4.6 Comparison of Selected Non-Sediment Pollutant Listed Waters to Targets (by stream segment)

Available sediment and habitat information on non-listed streams in some situations provides evidence to support the development of a TMDL. The following stream segments do not appear on the 303(d) List as pollutant affected waters however based upon clear information that sediment is a factor in the stream or that significant and obvious human related sediment sources exist in a watershed and there is a potential for reduction in the sediment loads, TMDLs will be developed.

5.4.6.1 Antelope Creek, headwaters to the mouth (MT76G002_140)

Percent fines were well above the target values for both categories of substrate composition, and width/depth ratios were slightly high. Pool habitat however was non-existent and the high percentage of bare ground, and the low percentage of shrub cover further describe a highly impacted, unnatural condition (**Table 5-20**).

Table 5-20. 2007 DEQ Sediment and Habitat Field Study – Selected Data for Antelope Creek

		Morphology		**Substrate Composition**		**Pool Habitat**		**Greenline**	
Site	**Gradient Category**	**W/D Ratio**	**Entrnch. Ratio**	**<2mm**	**<6mm**	**Residual Pool Depth**	**Pool Frequency**	**Percent Shrub Cover**	**Percent Bare Ground**
ANT-10	High	**16.1**	2.2	**39**	**65**	**-**	**0**	37	50

Antelope Creek was assessed near the mouth in an area used intensively as a horse pasture with little vegetation except weeds on the near-barren floodplain. The creek was dry downstream of the site and upstream of the Highway 273 crossing during the site visit on September 21, 2007. The streambanks were "laid back" due to horse access and were mostly bare, though there was a fringe of green vegetation along the channel margin. There was a high amount of fine sediment in the channel. There were no pools, with the reach being primarily a run with poorly defined riffles. There was mostly bare ground and grass along the narrow riparian margin, with some smaller shrubs, including rose and currant, and infrequently interspersed willows and alders. While this marked one of the more visibly impacted reaches in the Antelope Creek valley, the stream is paralleled closely by a road for much of its length and high fines were visually observed in riffles and pools throughout the stream. While not listed for sediment as a pollutant, a sediment TMDL will be developed based on the data and observed conditions of the stream.

5.4.6.2 Hoover Creek, Miller Lake to the mouth (MT76G005_082)

The lower DEQ site on Hoover Creek displayed very high percent fines for both categories of substrate composition. Pools were present but had limited residual pool depths. Width/depth ratio was lower than would be expected for this stream type but the dimensions may also have been altered as a result of channelization. Very low shrub cover on the banks is also indicative of a highly disturbed system (**Table 5-21**).

Two sites investigated by FWP resulted in "At Risk" ratings for both, and include low Fish Habitat scores (**Table 5-22**).

Table 5-21. 2007 DEQ Sediment and Habitat Field Study – Selected Data for Hoover Creek

		Morphology		**Substrate Composition**		**Pool Habitat**		**Greenline**	
Site	**Gradient Category**	**W/D Ratio**	**Entrnch. Ratio**	**<2mm**	**<6mm**	**Residual Pool Depth**	**Pool Frequency**	**Percent Shrub Cover**	**Percent Bare Ground**
HVR-16	Low	**5.5**	3.8	**34**	**71**	**0.5**	18	8	11

Table 5-22. 2007 FWP Stream Assessment Results for Hoover

Site Description	**DEQ Reach**	**Gradient Category**	**W/D Ratio**	**Geomorph Rating**	**Veg Rating**	**Fish Rating**	**All Considerations**
RM 2.4	HVR-14	High	9.3	70	77	43	70
RM 5.6	HVR-10	Low	9.3	90	70	30	73

The lower site on Hoover Creek was located downstream of a diversion that appeared to split the flow in two. The assessment was performed on the river right side of the valley and along the base of the foothill bench. It appeared that the channel was relocated to this spot, since it is in the center of the valley upstream of this reach. The general form resembled a ditch. Extensive pugging was observed with hoof shear along much of the river right bank. The upstream end of the reach is a bare area used as a watering source for cattle whose pasture is on the bench above the stream.

The 2009 FWP report also noted significant impacts to the stream in a few locations in lower Hoover Creek. "A formal evaluation was not completed near the mouth where spot electrofishing was done (near RM 0.2), but habitat was observed as being in a highly altered state at this location. Nearby transportation networks (railroad and Interstate 90), past land use, and a private residence all impacted the stream significantly. Channelization was evident as the stream was straight and bermed on each side. Riparian vegetation consisted primarily of grasses, sedges and disturbance-induced plants. Woody shrubs and tress were largely absent from the area. Upstream of Interstate 90 (RM 0.6), Hoover Creek flowed for over a mile through an irrigated hay meadow and pasture. Reviews of aerial photographs indicate that the stream had been highly manipulated and straightened through this reach as well. The stream lacked a significant riparian area and woody vegetation was rare."

At RM 2.4 some disturbance was noted as well, however banks appeared to be relatively stable. Riparian vegetation was nominal with a mix of woody riparian shrubs as well as a lack of deep-rooted vegetation and the common presence of noxious weeds. Also a lack of deep pools and high fine sediment accumulation limited habitat despite the presence of some areas of spawning gravels.

RM 5.6 found similar conclusions regarding the condition of Hoover Creek, characterized by some bank erosion from the lack of deep-rooted vegetation in some places, and the inconsistent presence of desirable riparian vegetation. In relation to habitat or morphology related target parameters, according to the 2009 FWP report, “Few pools or other holding water existed in the survey reach, and woody debris in the channel was virtually absent.”

Due to the findings from the DEQ and FWP, a TMDL will be developed for lower Hoover Creek.

5.4.6.3 Peterson Creek, Jack Creek to the mouth (MT76G002_132)

Most targets were met or only slightly exceeded at DEQ site PTR-15, although percent shrub and percent bare ground suggest some slight impact to the riparian area. However, two sites (P-1, P-3) reviewed as part of the East Valley report describe percent fines well above the targets for both parameters, as well as entrenched stream conditions (**Table 5-23**). Pool habitat and greenline was not conducted as part of the East Valley report.

Table 5-23. 2007 DEQ Sediment and Habitat Field Study; 2004 East Valley Watershed Report – Selected Data for Peterson Creek

		Morphology		**Substrate Composition**		**Pool Habitat**		**Greenline**	
Site	**Gradient Category**	**W/D Ratio**	**Entrnch. Ratio**	**<2mm**	**<6mm**	**Residual Pool Depth**	**Pool Frequency**	**Percent Shrub Cover**	**Percent Bare Ground**
PTR-15	Low	6.6	9.1	7	**24**	**0.6**	18	53	17
P-1	Low	10.3	**1.7**	**62**	**62**	-	-	n/a	n/a
P-3	Low	10.0	**2.0**	**37**	**66**	-	-	n/a	n/a

PTR-15 was located in an area that was described through conversations with landowners as the local dump for Deer Lodge at one time. Much of the creek upstream of this site was historically a beaver complex. This reach was located in a pasture that was being lightly grazed at the time of the site visit. It appeared that this section of stream may have been over-widened in the past, though wetland vegetation is now re-colonizing the bankfull channel margin and many of the streambanks were well vegetated and slightly undercut however, areas where cattle access the stream remain sediment sources. The channel was also over-widened in these areas. Dense willows along the channel provide bank stability where they occur and overhanging willows aids in pool formation, although residual pool depths were limited. There was a high amount of bare ground described in the Greenline assessment along the channel in areas with dense woody vegetation cover, though most of it was not disturbed by recent impacts, except small areas where there were livestock access points. Riparian vegetation included dense willows and alders, with wetland vegetation and reed canarygrass in the ground cover layer.

The conditions at site PTR-15 differ considerably from the two sites assessed in the 2004 Kirk report. In that study, sites P-1 and P-3 were conducted in locations that had very high fine substrate compositions and displayed some slight to moderate entrenchment. P-1 is located near the mouth of Peterson Creek, near Deer Lodge, and P-3 is located upstream of Burnt Hollow Creek, not far from and within the same reach as PTR-15. Aerial assessment of lower Peterson Creek show areas with significant lack of good riparian condition and site PTR-15 more likely represents conditions that would be desirable for the whole, rather than representative of the whole. Habitat conditions and substrate are close to desired conditions at PTR-15 however livestock grazing presents sediment sources and has altered channel morphology in some locations. Further downstream towards the mouth the stream becomes considerably more degraded as it flows near and through the town of Deer Lodge. As a result of this analysis, a TMDL will be developed for lower Peterson Creek.

5.4.6.4 Tin Cup Joe Creek, Tin Cup Lake to the mouth (MT76G005_110)

Although morphology categories meet the targets for Tin Cup Joe Creek, percent fines are relatively high for both categories of substrate composition, and residual pool depths are less than desirable for pool habitat. Additionally, percentages of shrub cover and bare ground as seen in the greenline assessment suggest disturbance to the riparian area that may contribute to sediment loads and target exceedences (**Table 5-24**).

Table 5-24. 2007 DEQ Sediment and Habitat Field Study – Selected Data for Tin Cup Joe Creek

		Morphology		**Substrate Composition**		**Pool Habitat**		**Greenline**	
Site	**Gradient Category**	**W/D Ratio**	**Entrnch. Ratio**	**<2mm**	**<6mm**	**Residual Pool Depth**	**Pool Frequency**	**Percent Shrub Cover**	**Percent Bare Ground**
TCJ-18	Low	12.0	2.3	**21**	**37**	**0.6**	14	56	18

This reach was located on the working ranch portion of the State Prison property and was used for grazing. There are also numerous irrigation transfers upstream, leading to an altered streamflow regime at the site. The stream was slightly entrenched and did not appear to access the historic floodplain. Pools were low quality and pool tail-outs contained substrate that was either too coarse or too fine to support spawning. Exposed streambanks were a sediment source, as were areas affected by hoof action. There was grass ground cover, with willows and alders in the understory, while invasive weeds were observed on the floodplain.

The witnessed bank erosion as a result of cattle grazing, and the relatively high percent fine results and low pool quality provide the basis for a sediment TMDL to be developed for Tin Cup Joe Creek.

5.4.6.5 Willow Creek, T4N, R10W, Sec 30 (DABC) to the mouth (MT76G002_062)

Sediment and habitat water quality targets are generally met for the lower section of Willow Creek. Some slight exceedences in percent fines <2mm, and low pool frequency at DEQ site WLW-19 serve as the only evidence of impact, however the greenline results, particularly at site WLW-19, and the overall ratings from the FWP assessment at both of their lower Willow sites suggest a stream "At Risk" and close to "Unsustainable" with the current conditions (**Tables 5-25, 5-26**).

Table 5-25. 2007 DEQ Sediment and Habitat Field Study – Selected Data for Willow Creek

		Morphology		**Substrate Composition**		**Pool Habitat**		**Greenline**	
Site	**Gradient Category**	**W/D Ratio**	**Entrnch. Ratio**	**<2mm**	**<6mm**	**Residual Pool Depth**	**Pool Frequency**	**Percent Shrub Cover**	**Percent Bare Ground**
WLW-13	Low	16.4	2.5	**15**	22	1.2	19	62	1
WLW-19	Low	16.8	3.1	**12**	22	1.4	**6**	6	0

Table 5-26. 2007 FWP Stream Assessment Results for Willow Creek

Site Description	**DEQ Reach**	**Gradient Category**	**W/D Ratio**	**Geomorph Rating**	**Veg Rating**	**Fish Rating**	**All Considerations**
RM 1.0	WLW-19	Low	15.9	70	52	30	56
RM 5.1	WLW-14	Low	**9.9**	63	63	30	59

WLW-13 was confined by a railroad crossing downstream of the site. There was a pasture to the river left side of the site, though it was fenced from the stream. Due to an extensive beaver complex, there were few riffles and the substrate was relatively fine. Downcutting of the channel and erosion was observed at one location in the reach, which was likely the result of one beaver dam overflowing and the water being forced to find a new pathway. Streambank erosion was associated with areas downstream of beaver dams and in ponded areas and the riparian zone included willows, grass and wetland vegetation. Active brook trout spawning was also observed in the tail of the first pool during the site visit on October 3, 2007.

WLW-19 on Willow Creek was located just downstream of the town of Opportunity in a large floodplain area that was likely affected by metals contaminated sediments from the upper Clark Fork basin. It appeared that the area was currently used for horse grazing. The channel was extremely sinuous and there were large eroding clay banks at the outsides of meander bends. The channel was slightly entrenched within the floodplain and somewhat over-widened in places. Visual observations of relatively fine sediment was noted through sections of the reach. Pools did contain potential spawning gravels. Grass was the primary riparian vegetation, with some wetland vegetation and a few willows.

The 2009 FWP assessment found the following:

- At RM 1.0, "Throughout the survey reach, the channel was rather wide and shallow, and there was a moderate amount of lateral erosion associated with banks lacking deep-rooted vegetation. The woody riparian community was comprised of mature willow, but plants were very patchy and sparse throughout the reach. Disturbance-induced plants and noxious weeds were commonly distributed throughout the riparian zone, and were the dominant stream bank vegetation throughout most of the reach. Fish habitat at RM 1.0 was rated only fair, and was most limited by a lack of deep pools and other forms of overhead cover. Much of the habitat was relatively simple and lacked complexity. Additionally, flow appeared somewhat low, and fine sediment accumulation was notable."

- At RM 5.1, "Portions of the survey reach were relatively incised (approximately 4-6 ft in places), and there was a moderate amount of lateral erosion evident throughout the area. Historic channel degradation appeared to have been rather severe and more accelerated than what was observed at the time of the survey. The woody riparian community was comprised of willow, alder, and wild rose, but plant density was patchy along the channel. Disturbance-induced grasses and weeds were relatively common throughout the riparian zone, and dominated the high banks that were effectively disconnected from the water table. Livestock use of accessible portions of the channel and riparian area was notable, and there were several areas of the stream that had been considerably over widened. Fish habitat at RM 5.1 was rated only fair, and was most limited by a lack of deep pools and other forms of overhead cover. Flow appeared fairly good in this reach of Willow Creek, but fine sediment accumulation was high."

Despite the sediment targets being met or close to the desired values for Willow Creek at the two DEQ sites, the observations in the field of both DEQ and FWP suggest significant improvements can be made in lower Willow Creek and therefore a TMDL will be developed.

5.4.7 TMDL Development Summary

Based upon the results of **Sections 5.4.5** and **5.4.6**, the following streams and stream segments will be included for TMDL development for sediment (**Table 5-27**). Sediment sources and estimates of sediment loads from those sources are investigated in **Section 5.5**, and the TMDLs and allocations of sediment load are presented in **Section 5.6**.

Table 5-27. Upper Clark Fork TPA water bodies included in sediment TMDL development

Water Body ID	Stream Segment	2008 Probable Causes of Impairment
MT76G002_140	**ANTELOPE CREEK,** headwaters to the mouth (Garnder Ditch)	*Low flow alterations*
MT76G005_100	**BROCK CREEK**, headwaters to the mouth (Clark Fork River)	**Sedimentation/siltation**
MT76G002_030	**CABLE CREEK**, headwaters to the mouth (Warm Springs Creek)	**Sedimentation/siltation**, *Other anthropogenic substrate alterations, Physical substrate habitat alterations*
MT76G002_100	**DEMPSEY CREEK**, the national forest boundary to mouth (Clark Fork River)	**Sedimentation/siltation**, *Alteration in stream-side or littoral vegetative covers*
MT76G005_081	**HOOVER CREEK**, headwaters to Miller Lake	**Sedimentation/siltation**, **Turbidity**

Table 5-27. Upper Clark Fork TPA water bodies included in sediment TMDL development

Water Body ID	Stream Segment	2008 Probable Causes of Impairment
MT76G005_082	**HOOVER CREEK**, Miller Lake to the mouth (Clark Fork River)	*Physical substrate habitat alterations*
MT76G002_131	**PETERSON CREEK**, headwaters to Jack Creek	**Sedimentation/siltation**, *Alteration in stream-side or littoral vegetative covers*
MT76G002_132	**PETERSON CREEK,** Jack Creek to the mouth (Clark Fork River)	*Alteration in stream-side or littoral vegetative covers, physical substrate habitat alterations*
MT76G002_040	**STORM LAKE CREEK**, headwaters to the mouth (Warm Springs Creek)	**Sedimentation/siltation**, *Alteration in stream-side or littoral vegetative covers*
MT76G005_110	**TIN CUP JOE CREEK**, Tin Cup Lake to the mouth (Clark Fork River)	*Low flow alterations*
MT76G005_112	**WARM SPRINGS CREEK**, (near Phosphate), from line between R9W and R10W to mouth (Clark Fork River)	**Sedimentation/siltation**, *Alteration in stream-side or littoral vegetative covers, Physical substrate habitat alterations*
MT76G002_061	**WILLOW CREEK**, Headwaters to T4N, R10W, Sec 30 (DABC)	**Sedimentation/siltation**, *Alteration in stream-side or littoral vegetative covers*
MT76G002_062	**WILLOW CREEK**, T4N, R10W, Sec 30 (DABC) to the mouth (Silver Bow Creek)	*Alteration in stream-side or littoral vegetative covers*

5.5 Source Quantification for all Water Bodies

Three major source categories of sediment have been identified in the Upper Clark Fork TPA. When developing TMDLs, sediment loads must be quantified for each of the significant source categories, and where appropriate, strategies for reducing those loads from human caused sources must be developed such that streams meet all applicable water quality standards. This section describes the methodology, rationale, and assumptions in sediment load quantification and load reduction that is used as the basis for TMDLs for the tributaries of concern in the Upper Clark Fork.

5.5.1 Bank Erosion

Rivers and streams are dynamic, ever changing systems that are constantly seeking equilibrium with its surrounding environment. The size, force, and shape of these flowing waters fluctuate throughout the seasons, and over the years. As streams shift across the landscape, they inevitably cut a new path by which to flow, sometimes very slowly and subtly, and sometimes very dramatic and obvious. The resultant sediment load from the erosion enters the stream and becomes a component of the equation by which the stream tries to find its balance. Sediment from eroding banks may alter channel shape, alter the erosive properties of the stream itself, prohibit or encourage aquatic life and fisheries, and affect water chemistry and quality.

Bank erosion as a result of these shifts in direction and energy is a natural and necessary function of an active stream channel. However, in some cases bank erosion can be exacerbated or accelerated by human activities on the landscape that result in altered bank stability or stream morphology. In investigating bank erosion as one source of the total watershed sediment load to derive the TMDL, methods were used to quantify sediment loads from eroding banks, identify the differences between naturally eroding banks and those associated with human activities, and apply loads across the landscape to derive appropriate bank erosion loads at the watershed scale.

5.5.1.1 Quantifying Pollutant Sources

In 2007, a field study was conducted throughout the Upper Clark Fork watershed that investigated the sediment and habitat conditions in selected reaches for the streams of interest. In preparation for that study, an aerial assessment and GIS exercise was conducted to characterize the streams into representative reaches categorized by geomorphologic constraints independent of the influence of man, and sub-categorized further by the apparent influences land use, land cover, and local activities may have on an individual reach. From this assessment, sites were chosen for study to represent the variability in natural and anthropogenic influences throughout the watershed. For each site that was selected as part of the 2007 field study, an assessment of eroding banks was conducted for the entire length of the study site (generally 1000’ in length), the data from which forms the basis for quantifying loads from individual banks and their associated conditions, and the extrapolated bank erosion load as a component of the Total Maximum Daily Load for sediment.

5.5.1.2 Bank Erosion Assessment

For each monitoring reach selected in the aerial photo assessment, measurements were collected to calculate the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS), in accordance with the Watershed Assessment of River Stability and Sediment Supply guidelines (Rosgen 2006). BEHI evaluates the susceptibility to erosion for multiple erosional processes. The process integrates multiple variables that relate to “combined” erosional processes leading to annual erosion rates. Erosion risk is then established for a variety of BEHI variables and is eventually used to establish corresponding streambank erosion rates. (Rosgen 2006)

As part of the field analysis, in addition to the information recorded for the physical character of the eroding bank and the near bank stress, each bank is categorized as either actively/visually eroding or slowly eroding/vegetated. Each bank is also assigned percent influence contributing to the erosion of the bank and distributed among natural and anthropogenic causes such as transportation, grazing, timber harvest, etc. Once sediment loading is generated for each analyzed bank in a given site, the sum of the bank loads is calculated to derive the total load for the sampled site.

5.5.1.3 Bank Erosion Sediment Loading

Using the information related to percent influence contributing to the bank erosion, all reaches were then segregated into two categories: Reaches dominated by “natural” influences on bank erosion, which includes all reaches that have 75% or more of the percent influence attributed to natural causes, and reaches dominated by anthropogenically influenced bank erosion which includes all reaches that have less than 75% of the eroding bank influence attributed to natural causes. The average total load was then derived for both of these categories (**Table 5-28**).

Table 5-28. Sediment Load Attributed to Natural and Anthropogenic Influenced Banks

Average Bank Erosion Load (Tons/Year) Per 1000’ in Upper Clark Fork TPA		
	Natural	**Anthropogenic**
	n=7	n=17
Actively/Visually Eroding Banks	3.6	9.4
Slowly Eroding/Vegetated Banks	2.1	2.8
All Banks	4.9	11.4

5.5.1.4 Establishing the Total Allowable Load

As the result of the aerial assessment and GIS reach stratification process, each identified reach includes information that attributes likely percent influence contributing to bank erosion. These determinations are based on best professional judgment, watershed reconnaissance, and visible land use/land cover as evidenced in the aerial photos and remote imagery. Every reach on every stream of interest is then defined either as anthropogenically influenced or naturally influenced (based on the criteria above), and the average load as determined from the field investigation is applied accordingly, and normalized to the length of the reach. The sum of the attributed loads to each reach on a stream is then calculated to determine the total sediment load from bank erosion for each stream. This sum per stream is referred to as the “existing” load.

To determine the total allowable load from bank erosion for each stream, the average total load from the “natural” influenced reach category is applied to the entire length of stream, for each of the streams of interest. An example is presented in **Table 5-29**.

Table 5-29. Example Bank Erosion Stream Load Derivation

	Stream Length (ft)	**Existing Load (Tons/year)**		**Allowable Load (Tons/year)**		**Reduction (Tons/year)**
Natural Influence:	10348	(*4.9/1000’)	51	(Length*4.9/1000’)	51	
Anthro Influence:	66654	(*11.4/1000’)	760	(Length*4.9/1000’)	327	
Total:	77002		811		378	433

The total allowable load from bank erosion is added to the total allowable load from the other significant sources in the watershed to derive the TMDL for sediment for each stream of interest.

5.5.1.5 Determining Allocations

The difference between the existing load and the total allowable load is the reduction from bank erosion necessary to achieve the TMDL. This reduction is distributed among the anthropogenic influences present throughout the watershed. In order to distribute the anthropogenically influenced bank erosion load among the sources, information from the stream reach stratification is reviewed. For every reach, the length of reach is divided among the associated influencing categories as were identified in the aerial assessment and stratification process. The lengths associated with each influence category are then totaled for the stream of interest, and the percentages of influence are determined and used to distribute the sediment load. An example is shown in **Table 5-30** and **Figure 5-1.**

It is acknowledged that the developed sediment loads and the method by which to attribute anthropogenic influence are estimates based on aerial photography, best professional judgment, and limited access to each stream reach. The assignment of bank erosion loads to the various causes is not definitive however it does provide helpful guides for directing focus and efforts at reducing the loads from those causes which are likely having the biggest impacts on the investigated streams.

Table 5-30. Peterson Creek Distribution Influence on Bank Erosion

		Natural		**Transportation**		**Grazing**		**Irrigation**	
Reach ID	**Reach Length**	**%**	**Length**	**%**	**Length**	**%**	**Length**	**%**	**Length**
PTR-01	2558	*50*	1279	*10*	256	*40*	1023	*0*	0
PTR-02	3306	*30*	992	*40*	1322	*30*	992	*0*	0
PTR-03	2060	*30*	618	*40*	824	*30*	618	*0*	0
PTR-04	3226	*20*	645	*60*	1936	*20*	645	*0*	0
PTR-05	2772	*30*	832	*40*	1109	*30*	832	*0*	0
PTR-06	1331	*30*	399	*50*	666	*20*	266	*0*	0
PTR-07	5029	*0*	0	*60*	3017	*20*	1006	*20*	1006
PTR-08	1793	*40*	717	*0*	0	*60*	1076	*0*	0
PTR-09	8630	*20*	1726	*0*	0	*80*	6904	*0*	0
PTR-10	3834	*40*	1534	*0*	0	*60*	2300	*0*	0
PTR-11	1661	*40*	664	*0*	0	*60*	996	*0*	0
PTR-12	4708	*20*	942	*10*	471	*70*	3295	*0*	0
PTR-13	14628	*0*	0	*10*	1463	*0*	0	*90*	13165
PTR-14	934	*0*	0	*0*	0	*0*	0	*100*	934
PTR-15	10532	*0*	0	*0*	0	*40*	4213	*60*	6319
PTR-16	9999	*0*	0	*40*	4000	*0*	0	*60*	6000
Total Length			10348		15063		24167		27424
% of Total Length			13%		20%		31%		36%

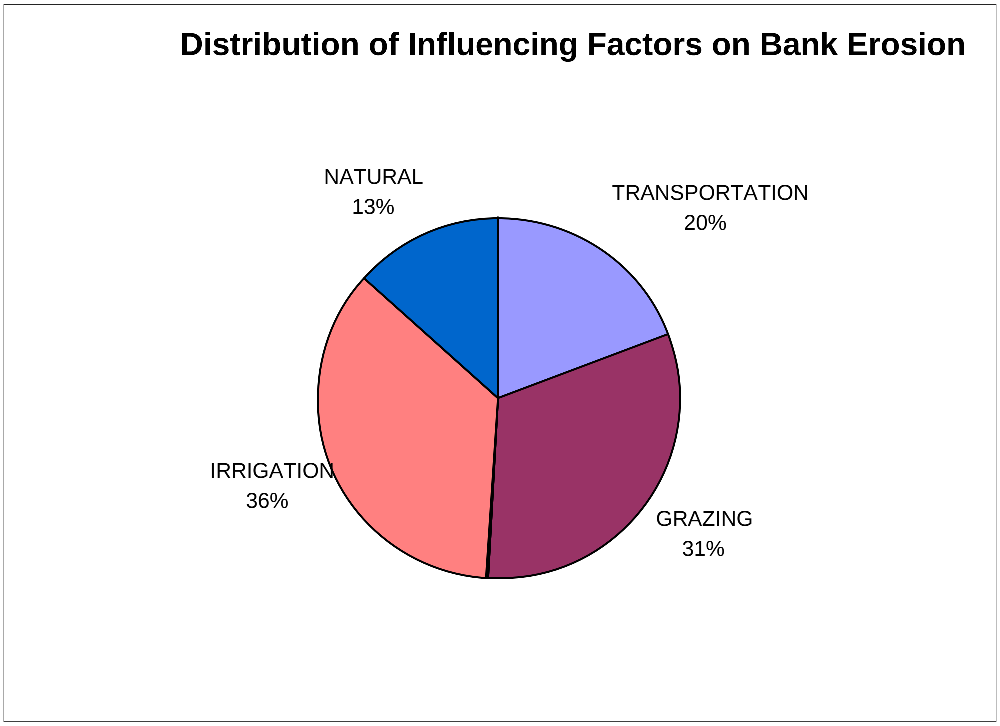


Figure 5-1. Example of Distribution of Bank Erosion Influencing Factors

5.5.1.6 Assumptions and Considerations

The average total load from "natural" influenced reaches and "anthropogenic" influenced reaches adequately represents the load expected from reaches designated in one of those two categories, when totaled for an entire watershed.

The criteria for splitting the load into two categories (natural and anthropogenic), does not preclude a particular reach from having any anthropogenic influence and in allowing a maximum of 25% anthropogenic influence for reaches considered natural this inherently incorporates a margin of safety as well as satisfies the allowance for all reasonable land, soil, and water conservation practices.

Average total loads were not determined at the Reach Category scale because the number of reaches per reach category was not felt to be statistically representative enough to appropriately characterize to this level.

The annual streambank erosion rates used to develop the sediment loading numbers were based on Rosgen BEHI studies developed in Colorado. While the predominant geologies between the Colorado research sites and the upper Clark Fork are different, they are similar enough in character to warrant their application.

5.5.2 Sediment from Roads

Roads located near stream channels can impact stream function through a degradation of riparian vegetation, channel encroachment, and sediment loading. Throughout the western United States, road networks are often a significant source of sediment due to their limited maintenance schedules, the dirt and gravel base materials of which they are often constructed, and the topography in which many rural, mountainous roads exist. In the Upper Clark Fork watershed, sediment from roads has been identified as one of three major source categories potentially affecting sediment loads in impaired tributary streams.

Numerous studies and methodologies have been employed to investigate sediment loading from roads over the years, throughout the United States. In 2008, DEQ compiled and reviewed a number of studies from previous Montana TMDLs and other western States in an attempt to identify trends and commonalities in the results of these studies which could be used to expedite the investigation and quantification of sediment from roads for the Upper Clark Fork watershed impaired tributaries. Although the methods and applications used throughout these studies varied, the results of that review did provide some information to apply to the Upper Clark Fork tributaries, and the subsequent loads and allocations were estimated accordingly.

5.5.2.1 Quantifying Sediment From Roads

In order to determine the amount of sediment from roads, computer models are often used that simulate road surface erosion response to the hydrology and climate for a given area. These models take into account weather, road condition, road shape, road orientation, topography, buffering vegetation, and other factors. Most models require a certain amount of known field evaluation to use as input parameters to derive the loads from discrete locations, however depending on the size of the watershed, a subset of the sediment load from roads may be based on real data, with the results of the model extrapolated to the remaining roads.

Over the years, varying models and methodologies have been developed to determine sediment loads from roads. Each variation has a slightly different approach, yet accounting for the amount of sediment that enters the stream, and the potential strategies to reduce that load remains the common thread. This is true in the TMDLs that have been developed in Montana and other western states as well, in that a consistent method throughout all TMDL studies has not been always applied. However, despite the differences, similarities between the road network conditions and environments in Montana watersheds, and basic information on which the models are based do exist. The results of these studies (specifically the reduction potential for decreasing road sediment loads), do allow for some cursory and basic comparisons.

In the Upper Clark Fork watershed, an aerial assessment was conducted for each of the sediment listed tributaries. In each subwatershed, relevant statistics related to miles of road, road type, road ownership, numbers of crossings, and road/stream proximity were calculated. A few significant statistics are provided in **Table 5-31**. These types of information are often used in sediment-source assessment methodology from roads and provide the basis of comparison to estimate sediment loads from roads in Upper Clark Fork sediment listed tributaries.

Table 5-31. Road Statistics for Streams in the Upper Clark Fork TPA

Watershed	Watershed Area (sq mi)	Road Density (mi/sq mi)	Number of Crossings	Road Miles	Within 100' of the stream
Antelope	4.9	2.9	16	14.3	2.8 (19.5%)
Brock	24.8	4.4	39	109.8	7.6 (6.9%)
Cable	7.6	5.6	13	42.9	3.1 (7.2%)
Dempsey	28.4	2.0	34	58.1	2.7 (4.5%)
Dunkleberg	15.3	3.2	28	49.2	2.9 (5.8%)
Gold	66.6	3.0	92	202.5	12.6 (6.2%)
Hoover	30.9	5.3	71	164.5	12.8 (7.8%)
Modesty	21.1	3.9	46	82.3	8.4 (10.1%)
Peterson	31.1	3.2	41	100.9	3.6 (3.6%)
Racetrack	51.5	1.9	43	96.3	3.8 (3.9%)
Storm Lake	9.2	4.6	14	42.3	2.0 (4.7%)
Tin Cup Joe	23.0	3.1	36	71.5	4.1 (5.7%)
Warm Springs	37.4	5.1	85	192.6	13.8 (7.0%)
Willow	14.9	4.0	53	60.0	7.1 (11.8%)

5.5.2.2 Sediment from Road Crossings

Often, the majority of sediment loading from roads occurs at road crossings. Road crossings may act as a direct conduit to the stream since these intersections of road and stream are natural drainage locations and often have limited capacity for buffering or diverting sediment laden runoff from the road. The contributing sediment load at road crossings is a function of the road length and condition that leads directly to the crossing, and the other physical and hydrologic characteristics of the immediate area. Addressing road/stream crossings and their contributing sediment load is an important component to managing the sediment load from road networks.

Three studies, conducted in Montana, and reviewed during the 2008 comprehensive road analysis investigation, derived average sediment loads per crossing. The Bitterroot Headwaters and Ninemile Headwaters TMDLs investigated sediment load per crossing using the FroS-SAM model, whereas the Prospect Creek TMDL used the X-DRAIN model. While some differences exist in the methodology and input variables between the two models, both models address road type and influencing condition (climate, soil type, buffer length, buffer gradient, and road width). Although annual precipitation and snowfall is slightly higher in the studied watersheds than in the UCF, in general, road conditions, ownership, and type are similar in many forested watersheds throughout Montana. In each study, a subset of road crossings were sampled throughout seven subwatersheds within each TPA, and an average sediment load (tons/year/crossing) was calculated for each subwatershed (**Table 5-32**). The average sediment load per subwatershed for all 21 subwatersheds studied equals 1.38 tons/year/crossing. This value will be applied to the road crossings in the Upper Clark Fork watershed as an average estimate of a component of the sediment contribution from roads in each listed tributary watershed.

Table 5-32. Road Crossing Studies in Previous Montana TMDL Development

Watershed	Model	HUC 6	Average Sediment Load (Tons/Year/Crossing)
Bitterroot Headwaters	FRoS-SAM	Buck	3.92
		Ditch	3.89
		Hughes	0.74
		Laird/Gilbert	0.76
		Moose	0.52
		Meadow	0.98
		Reimel	0.26
Ninemile Headwaters	FRoS-SAM	Big Blue Creek	2.45
		Josephine Creek	0.31
		McCormick Creek	0.71
		Kennedy Creek	3.56
		Stony Creek	5.39
		Cedar Creek	0.50
		Ninemile Creek	1.64
Prospect Creek	X-DRAIN	Clear Creek	0.42
		Cooper Creek	0.24
		Crow Creek	1.48
		Dry Creek	0.34
		Lower Prospect Creek	0.19
		Upper Prospect Creek	0.32
		Wilkes Creek	0.27
Average Sediment Load – Tons/Year/Crossing			1.38

5.5.2.3 Sediment from Parallel Segments

Sediment from road/stream crossings addresses the sediment contributed from discrete locations in a watershed where the road and stream intersect. However, road sediment from those sections of road which may not have a direct entry point to the stream channel is also considered in many source assessment studies and included with the overall sediment load quantification.

The amount of sediment from parallel road segments is often substantially limited and typically much less than the amount of sediment from road crossings. The amount of sediment from parallel segments is largely influenced by the distance of the road to the stream, the vegetation type and density between the road and the stream, and the topography (slope) near the road segment and the stream. The Washington Road Surface Erosion Model (WARSEM) applies percent delivery of sediment to the stream based on distance as follows:

- 100% load for direct delivery
- 35% delivery for roads within 100 feet
- 10% delivery for roads between 100-200 feet
- 0% delivery from drainage greater than 200 feet

In studies reviewed during the 2008 summary review, for those studies that quantified an average sediment load per mile, the numbers are almost negligible in comparison to the contribution from crossings. In a Shields TPA study, although parallel segments made up 41% of the total contributing road length (109.6 miles/267.4 miles), they generated 1.5% of the sediment load (4 tons/280 tons). Road crossings comprised the remainder (DEQ, 2008). In the Yaak TPA, parallel road segments were neglected for inclusion in the total sediment load as they produced such a low sediment yield. Studies in the Upper Jefferson quantified the average load (tons per mile) from parallel segments at 0.07 and 0.06 for roads classified within foothill areas and mountain areas respectively, and the Grave Creek TMDL segregated road types by usage (Primary and Secondary) and found sediment loads of 0.04 and 0.03. Based on these examples and the guidelines from the WARSEM model, estimates of sediment load from parallel road segments will not be derived for Upper Clark Fork Tributaries.

It is important to note however, that even though a sediment load is not being quantified for parallel segments, it does not preclude the entire road system for management improvements when addressing sediment load reductions and developing strategies for achieving the TMDL as sections of parallel road segments are inherently included within the approaches to the road/stream intersections that are quantified as part of the road crossing loads.

5.5.2.4 Establishing the Total Allowable Load

In reviewing the same studies that were used to derive the estimated existing load, a comparison of the potential load reduction amongst the studies also provides a reference for establishing the total allowable load. Potential load reduction is derived by simulating changes in road type, contributing road length, buffering vegetation, or other factors in the model that would predict the resultant sediment load if certain best management practices were implemented. In the studies reviewed to estimate the existing sediment load (Bitterroot Headwaters, Upper Jefferson, and Prospect Creek), a common reduction method scenario modelled road crossings with a maximum 200’ contributing length. (Prospect Creek based its reduction scenario on the results of the Ruby River and St Regis River TMDL.) The average percent reduction between those studies results in a 54.4% reduction of sediment load with the implementation of BMPs.

When broadening the scope of review amongst 13 of the reviewed studies, the average percent reduction was 54.7%. Regardless of the method used to quantify the sediment load, the potential for load reduction appears to be relatively consistent across watersheds in western Montana. Using previous TMDL road studies as a reference, the estimated total allowable load is derived for the Upper Clark Fork by applying a 55% reduction in sediment load from road crossings through the use of best management practices (with specific consideration to reducing the contributing road length for each crossing to 200 feet). Resultant estimated allowable loads are shown in **Table 5-33**.

Table 5-33. Road Sediment Calculations for Upper Clark Fork Streams

Subwatershed	Number of Crossings	Estimated Existing Sediment Load (tons/year)	Estimated Total Allowable Load (55% reduction)
Antelope	14	19.3	8.7
Brock	39	53.9	24.3
Cable	13	17.9	8.1
Dempsey	34	46.9	21.1
Hoover (_081)	49	67.7	30.5
Hoover (_082)	22	30.4	13.7
Peterson (_131)	19	26.2	11.8
Peterson (_132)	19	26.2	11.8
Storm Lake	14	19.3	8.7
Tin Cup Joe	36	49.7	22.4
Warm Springs (_112)	36	49.7	22.4
Willow (_061)	17	23.5	10.6
Willow (_062)	35	48.3	21.7

5.5.2.5 Determining Allocations

For each listed tributary in the Upper Clark Fork, road networks were identified and segregated by ownership. Because the road sediment load in the upper Clark Fork is estimated, and not based on data specific to each subwatershed, the most appropriate method for allocating the total allowable load is to distribute that load among those responsible for management of the roads. The total allowable load is simply partitioned among the ownership categories based on the percentage of road crossings identified within each category. **Table 5-34** provides an example using information from Antelope Creek.

It is recognized that in reality, in some cases the majority of the sediment load may come from only a few discrete locations within a watershed, or some roads may currently have some or all of their roads addressed with appropriate BMPs and the allocations may already have been met. It is expected however, that the derived sediment load and expected reductions in this document serve as a starting point for road management investigations, and a guideline for where to begin additional studies to improve and refine these estimates.

Table 5-34. Antelope Creek Road Ownership and Load Distribution

Road Ownership	Road Miles	Road Crossings	Existing Load	Allowable Load
Private/County	13.7	13	17.9	8.1
USFS	.01	-	-	-
State of MT	0.4	1	1.4	0.6
Unknown	0.2	-	-	-
Total	14.3	14	19.3	8.7

5.5.2.6 Assumptions and Considerations

The estimates and basic analysis used to derived sediment from roads in the Upper Clark Fork is a very simplistic approach that relies on the results of studies from other areas in western Montana, and the western United States. In order for this analysis to be considered a few assumptions must be recognized:

- Road networks in the Upper Clark Fork are similar to road networks in the other watersheds in western Montana.
- The studies used to derive the estimated sediment load per crossing provide a reasonable estimate for expected loads throughout the Upper Clark watershed.
- Focusing on road/stream crossings and their associated approaching road lengths will effectively reduce the majority of the sediment load from roads.
- Distributing the allocation of sediment loads among road ownership is the most pertinent approach given the current lack of on-the-ground information.
- There is a direct relationship between the number of crossings and the distribution in the miles of road, i.e. a land owner who has 80% of the roads in a given watershed is likely to have 80% of the road crossings in a watershed.
- Future on-the-ground data collection and modeling specific to the Upper Clark Fork TPA should also categorize crossings by road type and EPA landscape type (mountain, foothill, valley) to further refine the expected sediment load.
- BMPs may have already have been implemented on many roads and therefore the reductions necessary by land owner may be less than described in this document.

5.5.3 Upland Sediment

Nonpoint source pollution is pollution that originates over many varied and diffuse sources, as opposed to pollution delivered directly from a specific point or outlet, such as an end of pipe or chimney stack. Typically, this type of pollution is carried to streams and lakes through erosion via surface water (in the form of rainfall or snowmelt), ground water, or wind. It is often difficult to accurately quantify pollutant loads from the landscape when so much variability may exist across a watershed with regard to weather, vegetation, land use practices, soil types, geology, riparian condition, etc. However, while many complex processes are intertwined that determine this load, models with varying levels of complexity can be employed to represent the landscape and simulate the processes that occur that allow us to reasonably estimate sediment loads, identify where on the landscape those loads are coming from, and intimate how those loads could be reduced.

In the Upper Clark Fork, three main categories of pollution sources for sediment have been identified: sediment from roads, sediment from bank erosion, and sediment from upland sources. As sediment from bank erosion and sediment from roads have been addressed via alternative methods, the model is used to determine sediment from upland sources, and refers to the sediment from the landscape that is delivered to the stream via overland runoff from rainfall and snowmelt.

5.5.3.1 Quantifying Sediment from Upland Sources Using SWAT

The tool used in the Upper Clark Fork to determine the sediment loads from upland sources is the hydrologic simulation model known as SWAT (Soil and Water Assessment Tool). SWAT is a river basin scale model developed to quantify the impact of land management practices in large, complex watersheds. It incorporates hydrologic, climactic, and water chemistry data with detailed land cover/land use and topography information to predict pollutant loading for seasonal and annual time frames.

To simulate pollutant loading at the watershed scale, SWAT first partitions a watershed into a number of subbasins. Each subbasin delineated within the model is simulated as a homogeneous area in terms of climatic conditions, but with additional subdivisions within each subbasin to represent various soils and land use types. Each of these subdivisions is referred to as a hydrologic response unit (HRU) and is assumed to be spatially uniform in terms of soils, land use, topographic and climatic data. Once the HRU categories have been defined, the model then introduces the hydrologic and land management information in order to generate the sediment loads from the landscape. Data over a seven year period of record (1994-2000) from four stream gaging locations on the Clark Fork River was used to calibrate the hydrology for this model. The streamgaging locations used for calibration are Silver Bow Creek at Opportunity, Upper Clark Fork River at Deer Lodge, Little Blackfoot River at Garrison, and Upper Clark Fork River at Drummond.

SWAT uses a complicated approach but is built around the relatively simple concepts of the Universal Soil Loss Equation (USLE). USLE uses five main factors by which to estimate soil erosion: R * K* LS * C * P, where:

R = rainfall/intensity
K = erodibility
LS = length/slope
C = vegetation cover
P = field practices

Values for these factors were developed and applied to each of the HRUs in each of the subbasins. USLE values for the HRUs were derived based on literature values, estimates of existing field conditions in the watershed determined through site visits, communication with local stakeholders, and comparisons to previous SWAT model efforts in the nearby Ruby River watershed. HRU categories used in the Upper Clark Fork SWAT model are listed in **Table 5-35**.

Table 5-35. SWAT HRU Categories

SWAT Code	Land Cover/Land Use Description
ALFA	Alfalfa/Grass/Hay (typically irrigated)
BARN	Hobby Farm Livestock
FRSD	Deciduous Forest
FRSE	Evergreen Forest
FRST	Mixed Forest
LAWN	Hobby Farm Lawn

Table 5-35. SWAT HRU Categories

SWAT Code	Land Cover/Land Use Description
RNGB	Range Brush
RNGE	Range Grass
UIDU	Industrial
URHD	High Density Urban
URLD	Low Density Urban
URMD	Medium Density Urban
URML	Medium/Low Density Urban
WATR	Water
WETF	Wetland

5.5.3.2 Establishing the Total Allowable Load

From the model output, an average annual sediment load delivered to the stream is determined for each subbasin, (or listed stream watershed). The average annual upland sediment load is the sum of the average annual loads from each land cover/land use type (HRU category). This sediment load represents the best estimation of current conditions resulting in sediment from upland sources. **Table 5-36** below presents the modeled existing sediment load, with additional information to provide comparisons in severity of sediment loading between subbasins.

Table 5-36. Sediment Load from Upland Sources and Comparison Between Watersheds

Subbasin	Watershed Area (sq. mi.)	Delivered Sediment Load (tons/year)	Normalized to tons per square mile
Antelope	4.9	52	10.6
Brock	24.8	3238	130.6
Cable	7.6	206	27.1
Dempsey	28.4	9527	335.5
Hoover	30.9	604	19.5
Peterson	31.1	3666	117.9
Storm Lake	9.2	326	35.8
Tin Cup Joe	23.0	1523	66.2
Warm Springs	37.4	1986	53.1
Willow	14.9	487	32.6

The initial model outputs represent an estimate of current conditions and practices that result in the upland sediment load. To determine the total allowable load from upland sources, land use/land cover categories where management practices could be improved are modified to represent those changes on the landscape, and the SWAT model is run again to simulate the resultant sediment loads that exist when all reasonable land, soil, and water conservation practices are employed.

For the purposes of this assessment, only a few land use categories were modified. These include barnyard, range brush and range grass. It is assumed that in the Upper Clark TPA, these land use categories have real potential for improvement and are often not meeting all applicable land, soil, and water conservation practices. The sediment contributions from the other land uses in the Upper Clark Fork TPA are presumed to be either negligible in its contribution, or with little potential for altering the current management to reduce sediment contribution from the existing load.

Three scenarios were run in the model. The baseline scenario represents the existing conditions and subsequent sediment loads for most watersheds in the Upper Clark Fork TPA. The improved condition scenario represents the changes that would occur with improved land management practices, including restoration of the riparian buffers to filter sediment from the landscape. Lastly, a “severe baseline” scenario was run. The severe baseline sediment loads were used as the existing condition in those watersheds where grazing was observed to be of a significantly higher impact than in other watersheds. In developing TMDLs, the severe baseline sediment loads were only used for Antelope Creek and Dempsey Creek. Additional detail regarding the assumptions used in the development of the current conditions and improvement scenario is presented in **Appendix F**.

5.5.3.3 Incorporating Improved Riparian Condition

Aerial assessment techniques using GIS and aerial photos were completed for each stream of interest to provide a coarse summary of riparian conditions in the subbasins. Delineated reaches were given a riparian condition category of good, fair, or poor based on land use adjacent to the stream, riparian vegetation type and density, and the presence or absence of human related activities near the stream corridor. Based on this, each stream investigated was given corresponding percentages of condition based on the total length of stream assessed.

Literature review (Wegner 1999, Knutson and Naef 1997) indicates that a 100 foot wide, well vegetated riparian buffer zone can be expected to filter 75-90% of incoming sediment from reaching its stream channel. Conversely, this analysis conservatively assumes that a riparian zone without vegetation cover (corresponding to a riparian health assessment of ‘none’) would only filter 10% of incoming sediment from reaching its stream.

Based on the above information, sediment reduction factors were chosen to account for the potential in sediment reduction efficiency from improved riparian conditions. The range between filtering capacity between ‘good’ and ‘none’ is roughly 65-80%. A conservative assumption was then made that sediment reduction potential representing ‘poor’ conditions may be close to 25%, ‘moderate’ riparian condition filters 50% of the sediment load, and ‘good’ riparian condition has the effect of reducing upland sediment load by 75%.

To then incorporate riparian filtering capacity, in addition to the load from the improved condition scenario as described in **Section 5.5.3.2**, the riparian condition and associated reduction potential for each stream is applied to simulate the total sediment reduction potential if all land management improvements across the landscape and within the riparian corridor are implemented. For instance, if stream A is determined by the SWAT model desired condition to have a sediment load of 100 tons/year, and 50% (50 tons/year) of the stream is considered to be in Good riparian condition, and 50% (50 tons/year) is considered to be Poor, than a total of 50% (25 tons/year) of the load from the Poor riparian could be buffered if the riparian condition was improved to Good, resulting in a total load for stream A of 75 tons/year when all best management practices are implemented (**Table 5-38**). The filtering capacity of the buffers is only applied in the improvement scenarios. Since the model serves only as a representation of existing conditions, it is implied that additional reduction through riparian filters is only applicable once modifications in land management improve riparian condition.

Table 5-37. Example Riparian Buffer Load Reduction Estimate

Riparian Condition			**Buffering Capacity**	
Category	**Percent Stream Length**	**Upland Load Distribution**	**Estimated Load Reduction with Buffer Improvement**	**Upland Load Reduction**
Good	50%	50	0%	50
Fair	-	-	25%	-
Poor	50%	50	50%	25
Upland Load From Model		100	Desired Load	75

5.5.3.4 Determining Allocations

The upland sediment loads are estimations based on the land uses that exist within a watershed, as well as other factors that drive sediment production as described earlier in this section. Further assumptions are made regarding the riparian condition and the ability for improved riparian conditions to effectively reduce sediment loading to the stream. For the purposes of allocating the load amongst the sources, a very simplistic approach is taken here: the total sediment load from upland erosion is portioned amongst the land use sources based on the percent contribution of each land use. For example, the model output determined an existing upland sediment load of 100 tons/year coming from four sources: agricultural land (40 tons), forest (30 tons), range (20 tons), and rural residential (10 tons). Therefore the allocation of the total desired load amongst the existing land uses is a 40%, 30%, 20%, 10% split, respectively.

It is fully acknowledged however that this simplistic approach may not represent the true potential for that load reduction within a particular land use. Geography, the association of the riparian conditions to the various land uses, the actual potential for the application of best management practices within a given land use, may all be factors that would otherwise alter the reduction potential of a given source. However, at this most basic scale, this approach does identify the relative contributions among the land use categories and therefore serves as an initial starting point by which to focus sediment reduction efforts and assess those areas most likely to be affecting the stream, and most likely to have the potential for improvement.

5.5.3.5 Assumptions and Considerations

As with any modeling effort, and especially when modeling at a watershed scale, there are a number of assumptions that must be accepted. For the Upper Clark Fork, the following points serve as some of the more significant considerations:

- The input variables used in the USLE calculations are representative of their respective land use conditions.

- The land management practices (grazing duration, hay cutting, etc) for certain land use categories that define the vegetative cover throughout the year are relatively consistent and representative of practices throughout the watershed.
- The application of riparian filtering is applicable only to the improved conditions and the current model inherently incorporates existing conditions across the landscape.
- The riparian condition as estimated through the aerial assessment is representative of on-the-ground conditions.
- The improvement scenarios to riparian condition and land management are reasonable and achievable.

5.6 TMDL and Allocations (by stream)

The sediment TMDLs for all streams and stream segments presented below are expressed as a yearly load, and a percent reduction in the total yearly sediment loading achieved by applying the load allocation reductions identified in the associated tables. These reductions address both coarse and fine sediment loading to ensure full protection of beneficial uses. The allocations are based on information provided from the source assessment analyses used within this document, and a determination that these approximate source load reductions for each stream or segment of interest, and its contributing tributaries, will cumulatively account for the total percent reduction needed to meet the TMDL, and is achievable by addressing the major human caused sources described in this section. The sediment load allocations and associated rationale behind the allocations are described in **Section 5.5** and **Appendix I**. Due to the uncertainty and assumptions associated with the methods used to determine sediment loads, the specific annual loads should not necessarily be recognized as an exact quantification. However the percent reductions presented offer a valuable and more conceivable goal for watershed restoration planning purposes and an accurate representation of the *degree* of sediment reduction that would result from the implementation of this plan. As required by EPA, TMDLs must also be expressed as actual daily loads. Information on interpreting these values into “daily” sediment loads is presented in **Appendix C**.

Sediment from upland erosion in the following tables (**Tables 5-39 through 5-51**) is represented as the sum of upland sediment load from each of the land uses within that watershed. This category, by default, incorporates both sediment loads influenced by anthropogenic activities and natural loads. However, within the context of TMDL development and Montana state law, we can interpret the natural load to be the load that results when all reasonable land, soil, and water conservation practices are applied, which in this case, also equates to the sediment load allocation.

A TMDL is determined by the sum of the Waste Load Allocation (WLA), Load Allocation (LA), and Margin of Safety (MOS). Waste Load Allocations are derived for specific point sources, often which require local, state, or federal permits that put limits on the amount of a particular pollutant that a nearby water body can receive. Tin Cup Joe Creek is the only stream of interest listed for sediment pollution and affected by a WLA. The WLA for Tin Cup Joe Creek is described in detail in **Section 5.6.10**.

5.6.1 Antelope Creek (MT76G002_140)

Table 5-38. Antelope Creek Sediment TMDL

Sources		Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Roads		19	9	55%
Eroding Banks	Anthropogenically Influenced	366	157	57%
	Natural	-	-	
Upland Erosion	All Land Uses	52	34	35%
Total Sediment Load		437	200	54%

5.6.2 Brock Creek (MT76G005_100)

Table 5-39. Brock Creek Sediment TMDL

Sources		Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Roads		54	24	56%
Eroding Banks	Anthropogenically Influenced	519	223	48%
	Natural	100	100	
Upland Erosion	All Land Uses	3238	2234	31%
Total Sediment Load		3911	2581	34%

5.6.3 Cable Creek (MT76G002_030)

Table 5-40. Cable Creek Sediment TMDL

Sources		Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Roads		18	8	56%
Eroding Banks	Anthropogenically Influenced	191	82	40%
	Natural	82	82	
Upland Erosion	All Land Uses	206	145	30%
Total Sediment Load		497	317	46%

5.6.4 Dempsey Creek (MT76G002_100)

Table 5-41. Dempsey Creek Sediment TMDL

Sources		**Current Estimated Load (Tons/Year)**	**Sediment Load Allocation (Tons/Year)**	**Sediment Load Allocation – Expressed as Percent Reduction**
Roads		47	21	55%
Eroding Banks	Anthropogenically Influenced	557	239	42%
	Natural	209	209	
Upland Erosion	All Land Uses	9527	5680	40%
Total Sediment Load		10,340	6149	41%

5.6.5 Hoover Creek, upper (MT76G005_081)

Table 5-42. Hoover Creek Sediment TMDL

Sources		**Current Estimated Load (Tons/Year)**	**Sediment Load Allocation (Tons/Year)**	**Sediment Load Allocation – Expressed as Percent Reduction**
Roads		68	31	54%
Eroding Banks	Anthropogenically Influenced	292	125	54%
	Natural	18	18	
Upland Erosion	All Land Uses	205	136	34%
Total Sediment Load		583	310	47%

5.6.6 Hoover Creek, lower (MT76G005_082)

Table 5-43. Hoover Creek Sediment TMDL

Sources		**Current Estimated Load (Tons/Year)**	**Sediment Load Allocation (Tons/Year)**	**Sediment Load Allocation – Expressed as Percent Reduction**
Roads		30	14	56%
Eroding Banks	Anthropogenically Influenced	335	144	55%
	Natural	15	15	
Upland Erosion	All Land Uses	399	260	35%
Total Sediment Load		779	433	45%

5.6.7 Peterson Creek, upper (MT76G002_131)

Table 5-44. Peterson Creek Sediment TMDL

Sources		**Current Estimated Load (Tons/Year)**	**Sediment Load Allocation (Tons/Year)**	**Sediment Load Allocation – Expressed as Percent Reduction**
Roads		26	12	54%
Eroding Banks	Anthropogenically Influenced	306	131	50%
	Natural	46	46	
Upland Erosion	All Land Uses	1906	1339	30%
Total Sediment Load		2284	1528	33%

5.6.8 Peterson Creek, lower (MT76G002_132)

Table 5-45. Peterson Creek Sediment TMDL

Sources		**Current Estimated Load (Tons/Year)**	**Sediment Load Allocation (Tons/Year)**	**Sediment Load Allocation – Expressed as Percent Reduction**
Roads		26	12	54%
Eroding Banks	Anthropogenically Influenced	454	195	56%
	Natural	5	5	
Upland Erosion	All Land Uses	1760	1236	30%
Total Sediment Load		2245	1448	36%

5.6.9 Storm Lake Creek (MT76G002_040)

Table 5-46. Storm Lake Creek Sediment TMDL

Sources		**Current Estimated Load (Tons/Year)**	**Sediment Load Allocation (Tons/Year)**	**Sediment Load Allocation – Expressed as Percent Reduction**
Roads		19	9	53%
Eroding Banks	Anthropogenically Influenced	406	175	45%
	Natural	102	102	
Upland Erosion	All Land Uses	326	225	31%
Total Sediment Load		853	511	40%

5.6.10 Tin Cup Joe Creek (MT76G005_110)

Table 5-47. Tin Cup Joe Creek Sediment TMDL

Sources		**Current Estimated Load (Tons/Year)**	**Sediment Load Allocation (Tons/Year)**	**Sediment Load Allocation – Expressed as Percent Reduction**
Point Sources	Montana State Prison Ranch	0	0*	0%
	Sun Mountain Lumber Co.	0	5*	0%
Roads		50	22	56%
Eroding Banks	Anthropogenically Influenced	387	166	36%
	Natural	220	220	
Upland Erosion	All Land Uses	1681	1327	21%
Total Sediment Load		2338	1740	26%

*Under typical rainfall conditions. For rainfall events equivalent to a 25-year storm or greater, TSS load allocations will be achieved by following MPDES permit requirements.

** This allocation represents the maximum allowable load under the constraints of the current Storm Water permit issued to Sun Mountain Lumber Co. Full compliance with all conditions of the permit should achieve a load considerably less than this amount.

Two point source permits were identified in the Tin Cup Joe Creek watershed and are included in the calculation for TMDL development.

CAFO Permit

The Montana State Prison Ranch operates under a Concentrated Animal Feeding Operation General Permit. In addition to the general permit requirements, the permit for the Montana State Prison Ranch includes additional considerations which must be met, two of which are observed here in the development of the sediment TMDL for Tin Cup Joe Creek:

1) The facility must be designed, constructed, and operated to contain all process generated wastewaters, plus the precipitation from the runoff of a 25-year, 24-hour rain event. The weather station to determine the amount of precipitation that occurs at the facility shall be the DEER LODGE, MT (DRLM). The permittee has the option of maintaining a comparable precipitation gauge at the facility.
2) The facility shall prepare an annual waste management plan (AR2) that is site specific and addresses manure and wastewater handling and storage, land application of manure and other nutrient sources, site management, record keeping, and other items outlined in the report.

Compliance with the Concentrated Animal Feeding Operation General Permit, and the associated DEQ approved annual waste management plan (AR2) constitute the meeting of all TMDL requirements for sediment for this facility. Under the conditions of the permits, all pollutants are to be contained on site during any and all storm events less than a 25-year, 24 hour rain event.

Therefore the TMDL is 0 for this source, under typical rainfall events (less than 25-year storm event). For any rainfall events equivalent to a 25-year, 24 hour duration or greater, full compliance with permit requirements assumes the pollutant load that may enter Tin Cup Joe Creek is acceptable.

Storm Water Discharge Permit
The Sun Mountain Lumber Company operates under the General Permit for Storm Water Discharges Associated with Industrial Activity. Under the stipulations of that permit, the facility maintains an approved Storm Water Pollution Prevention Plan (SWPPP). The SWPPP sets forth the procedures, methods, and equipment used to prevent the pollution of storm water discharges from the facility. In addition, this SWPPP describes general practices used to reduce pollutants in storm water discharges.

According to **Attachment B** (Monitoring Parameter Benchmark Concentrations) within the general storm water permit, the target concentration for TSS is 100 mg/l. The SWPPP for the Sun Mountain Lumber Co. provides information pertaining to site conditions and average annual precipitation. Based on this information, the annual average precipitation for this site is 14.5 inches of rainfall. The majority of the facility drains away from Tin Cup Joe Creek (toward the Clark Fork River), however an area of approximately 3 acres drains the northwest corner of the facility to Tin Cup Joe Creek. If we were to theorize a worst-case scenario using the condition of the target concentration (100mg/l), the maximum allowable annual sediment load from this site would equate to approximately 4.9 tons/year. This load is equivalent to only 0.3% of the annual TMDL. Compliance with the general permit and SWPPP constitute satisfying the TMDL for this facility. The true load, assuming compliance with all permit requirements, is likely to be considerably less and is generally an insignificant contribution to the overall load to Tin Cup Joe Creek. It should be noted however that impacts may occur to discrete areas of the stream in the immediate vicinity of the facility, and under all circumstances compliance with the permit should be achieved, with the goal of minimizing sediment discharge from the site to the greatest extent possible.

5.6.11 Warm Springs Creek, near Phosphate, lower (MT76G005_112)

Table 5-48. Warm Springs Creek Sediment TMDL

Sources		**Current Estimated Load (Tons/Year)**	**Sediment Load Allocation (Tons/Year)**	**Sediment Load Allocation – Expressed as Percent Reduction**
Roads		50	22	56%
Eroding Banks	Anthropogenically Influenced	342	147	55%
	Natural	15	15	
Upland Erosion	All Land Uses	811	538	34%
Total Sediment Load		1218	722	41%

5.6.12 Willow Creek, upper (MT76G002_061)

Table 5-49. Willow Creek Sediment TMDL

Sources		Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Roads		25	11	54%
Eroding Banks	Anthropogenically Influenced	101	43	30%
	Natural	95	95	
Upland Erosion	All Land Uses	262	197	25%
Total Sediment Load		483	346	28%

5.6.13 Willow Creek, lower (MT76G002_062)

Table 5-50. Willow Creek Sediment TMDL

Sources		Current Estimated Load (Tons/Year)	Sediment Load Allocation (Tons/Year)	Sediment Load Allocation – Expressed as Percent Reduction
Roads		48	22	54%
Eroding Banks	Anthropogenically Influenced	465	200	56%
	Natural	5	5	
Upland Erosion	All Land Uses	224	159	29%
Total Sediment Load		742	386	48%

5.7 Seasonality and Margin of Safety

All TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety into the load allocation process to account for uncertainties in pollutant sources and other watershed conditions, and to ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes seasonality and margin of safety in the Upper Clark Fork TPA tributary sediment TMDL development process.

5.7.1 Seasonality

The seasonality of sediment impact to aquatic life is taken into consideration in the analysis within this document. Sediment loading varies considerably with season. For example, sediment delivery increases during spring when snowmelt delivers sediment from upland sources and the resulting higher flows scour streambanks. However, these higher flows also scour fines from streambeds and sort sediment sizes, resulting in a temporary decrease in the proportion of deposited fines in critical areas for fish spawning and insect growth. While fish are most susceptible to fine sediment deposition seasonally during spawning, fine sediment may affect aquatic insects throughout the year. Because both fall and spring spawning salmonids reside in the Upper Clark Fork TPA, streambed conditions need to support spawning through all seasons. Additionally, reduction in pool habitat, by either fine or coarse sediment, alters the quantity and quality of adult fish habitat and can, therefore, affect the adult fish population throughout the year. Thus, sediment targets are not set for a particular season, and source characterization is geared toward identifying average annual loads. Annual loads are appropriate because the impacts of delivered sediment are a long-term impact—once sediment enters the stream network, it may take years for sediment loads to move through a watershed. Although an annual expression of the TMDLs was determined as the most appropriate timescale to facilitate TMDL implementation, to meet EPA requirements daily loads are provided in **Appendix C**.

5.7.2 Margin of Safety

Incorporating a margin of safety (MOS) is a required component of TMDL development. The MOS accounts for the uncertainty between pollutant loading and water quality and is intended to ensure that load reductions and allocations are sufficient to sustain conditions that will support beneficial uses. MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (EPA, 1999). This plan incorporates an implicit MOS in a variety of ways:

- By using multiple targets to help verify beneficial use support determinations and assess standards attainment after TMDL implementation. Conservative assumptions were used during target development (see **Section 5.4.1**).
- By using standards, targets, and TMDLs that address both coarse and fine sediment delivery.
- By using supplemental indicators (Greenline) that act as an early warning method to identify pollutant-loading threats, which may not otherwise be identified, if targets are not met. Conservative assumptions were used for the source assessment process, including erosion rates, sediment delivery ratio, and BMP effectiveness (see **Appendices D**, **E**, **F** and **G**).
- By considering seasonality (discussed above).
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, targets, modeling assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development (discussed below and in **Section 6** and **7**).
- By using naturally occurring sediment loads as described in ARM 17.30.602(17) to establish the TMDLs and allocations. This includes an allocation process that addresses all known human sediment causing activities, not just the significant sources.

5.7.3 Uncertainty and Adaptive Management

A degree of uncertainty is inherent in any study of watershed processes related to sediment. The assessment methods and targets used in this study to characterize impairment and measure future restoration are each associated with a degree of uncertainty. This TMDL document includes monitoring and adaptive management stratagies to account for uncertainties in the field methods, targets, and supplemental indicators. For the purpose of this document, adaptive management relies on continued monitoring of water quality and stream habitat conditions, continued assessment of impacts from human activities and natural conditions, and continued assessment of how aquatic life and coldwater fish respond to changes in water quality and stream habitat conditions. Adaptive management addresses important considerations, such as feasibility and uncertainty in establishing targets. For example, despite implementation of all restoration activities (**Section 9**), the attainment of targets may not be feasible due to natural disturbances, such as forest fires, flood events, or landslides.

The targets established in the document are meant to apply under median conditions of natural background and natural disturbance. The goal is to ensure that management activities achieve loading approximate to the TMDLs within a reasonable timeframe and prevent significant excess loading during recovery from significant natural events. Additionally, the natural potential of some streams could preclude achievement of some targets. For instance, natural geologic and other conditions may contribute sediment at levels that cause a deviation from numeric targets associated with sediment. Conversely, some targets may be underestimates of the potential of a given stream and it may be appropriate to apply more protective targets upon further evaluations. Supplemental indicators are used to help with these determinations. In these circumstances, it is important to recognize that the adaptive management approach provides the flexibility to refine targets and supplemental indicators as necessary to ensure protection of the resource and to adapt to new information concerning target achievability.

Sediment limitations in many streams in the Upper Clark Fork TPA relate to a fine sediment fraction found on the stream bottom, while sediment modeling employed in the Upper Clark Fork TPA examined all sediment sizes. In general, roads and upland sources produce mostly fine sediment loads, while streambank erosion can produce all sizes of sediment. Because sediment source modeling may under- or over-estimate natural inputs due to selection of sediment monitoring sections and the extrapolation methods used, model results should not be taken as an absolutely accurate account of sediment production within each watershed. Instead, source assessment model results should be considered used as a tool to estimate sediment loads and make general comparisons of sediment loads from various sources.

Cumulatively, the source assessment methodologies address average sediment source conditions over long timeframes. Sediment production from both natural and human sources is driven by storm events. Pulses of sediment are produced periodically, not uniformly, through time. Separately, each source assessments methodology introduces different levels of uncertainty. For example, the road erosion method focuses on sediment production and sediment delivery locations from yearly precipitation events. The analysis did not include an evaluation of road culvert failures, which tend to add additional sediment loading during large flood events and would, therefore, increase the average yearly sediment loading if calculated over a longer time period. The bank erosion method focuses on both sediment production and sediment delivery and also incorporates large flow events via the method used to identify bank area and retreat rates. Therefore, a significant portion of the bank erosion load is based on large flow events versus typical yearly loading. The hillslope erosion model focuses primarily on sediment production across the landscape during typical rainfall years. Sediment delivery is partially incorporated based on distance to stream. The significant filtering role of near-stream vegetated buffers (riparian areas) was incorporated into the hillslope analysis, resulting in proportionally reduced modeled sediment loads from hillslope erosion relative to the average health of the vegetated riparian buffer throughout the watershed.

Because the sediment standards relate to a water body's greatest potential for water quality given current and historic land use activities where all reasonable land, soil, and water conservation practices have been applied and resulting conditions are not harmful, detrimental, or injurious to beneficial uses, the percent-reduction allocations are based on the modeled upland and riparian BMP scenarios for each major source type. The allocations reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments. However, if new information becomes available regarding the feasibility or effectiveness of BMPs, adaptive management allows for the refinement of TMDLs and allocations.

Additionally, as part of this adaptive management approach, shifts in the amount or intensity of land use activities should be tracked and incorporated into the source assessment to determine if allocations need to be revised. Cumulative impacts from multiple projects must also be considered. This approach will help track the recovery of the system and the impacts, or lack of impacts, from ongoing management activities in the watershed. Under these circumstances, additional targets and other types of water quality goals may need to be developed to address new stressors to the system, depending on the nature of the activity.

SECTION 6.0
TEMPERATURE

This portion of the document focuses on temperature as an identified cause of water quality impairment in the Upper Clark Fork Tributaries TPA. It describes: 1) the mechanisms by which temperature impairs beneficial uses of streams, 2) the specific stream segments of concern, 3) the presently available data pertaining to temperature impairments in the watershed, 4) the various contributing sources of temperature impairment (thermal load) based on recent studies, and 5) the temperature TMDLs, allocations and margin of safety.

6.1 Thermal Impacts upon Sensitive Uses

Human influences which reduce stream shade, increase stream channel width and decrease the ability of the stream to regulate solar heating all increase stream temperatures. Heated conditions have negative impacts upon aquatic life and fish which depend upon cool water for survival. Warm water temperatures exert more stress on fish by impacting metabolism and reducing the amount of oxygen available in the water. This in turn may cause cold water fish species to reduce feeding rates and use additional energy to survive in thermal conditions above the tolerance ranges to which they have adapted.

Special temperature considerations are warranted for the westslope cutthroat trout, which are listed by the State of Montana as a species of concern (MNHP 2009). Recently conducted research by Bear et. al (2005) found the upper incipient lethal temperature (UILT) for Westslope Cutthroat is 67ºF (19.6ºC). The UILT is the temperature that is considered to be survivable indefinitely by 50 percent of the westslope cutthroat population (Lohr et. al.1996). Peterson Creek biological community assessments have shown a presence of Westslope cutthroat trout.

6.2. Stream Segments of Concern

Only one water body segment in the Upper Clark Fork Tributaries TPA appeared on the 2006 Montana 303(d) List due to temperature related impairments. The lower segment of Peterson Creek (from Jack Creek to the mouth) was identified as impaired by temperature. A thermal loading TMDL will be completed for this water body.

6.3 Information Sources and Existing Condition Summary

6.3.1 Temperature

The lower segment of Peterson Creek (Jack Creek to the mouth) was listed as impaired due to temperature on the 2006 303(d) List. Data reviewed in the impairment status determination described a 9 degree increase in stream temperatures in the last mile of the stream alone.

The East Valley Watershed Report (Kirk Environmental, 2003) describes loss of riparian cover and irrigation water withdrawal as suspected probable causes of temperature issues in Peterson Creek during the hottest month in the summer in at least the middle section of Peterson Creek at

Monitoring Site P3 (between Burnt Hollow Creek and Jack Creek). For the period monitored in 2002, a total of 17 days were above 70 degrees Fahrenheit, which does not include July or early August temperature data.

The most robust data set available for temperature in Peterson Creek was collected during the 2007 field season. Temperature data loggers were placed at 11 sites in the Peterson Creek watershed during the summer of 2007, including eight mainstem locations and three tributaries. Data loggers were deployed between July 16th and 18th and retrieved on September 26th. One mainstem temperature data logger was lost (PTR-04) and one tributary data logger did not work properly (PTR-02) resulting in continuous temperature data for seven Peterson Creek sites and two tributary streams. The maximum daily temperature and the 7-day average maximum temperature data were reviewed to identify the warmest period of the season. Maximum daily temperatures occurred between July 19th and 28th, depending on the site, while the maximum 7-day average maximum temperature occurred between July 20th and 22nd. Multiple days above 70 degrees F occurred at all sampling locations and no 7-day average maximum occurred below 67 degrees for any site. (PTR-05 was located at the mouth of Jack Creek and PTR-11 was located at the mouth of Burnt Hollow Creek) **Table 6-1**.

Table 6-1. DEQ Peterson Creek 2007 Temperature Data Summary

Site ID	Start	Stop	Seasonal Max.		7-Day Averages				Days >
			Date	Value	Date	Max	Min	Delta T	70 F
PTR-05	7/18/07	9/25/07	7/20	72.5	7/21	71.1	59.8	11.3	9
PTR-07	7/18/07	9/25/07	7/20	73.4	7/21	71.8	63.2	8.6	14
PTR-09	7/18/07	9/25/07	7/28	74.4	7/21	72.5	62.5	10.0	14
PTR-11	7/18/07	9/25/07	7/22	76.0	7/21	74.0	59.5	14.5	16
PTR-12	7/19/07	9/25/07	7/20	75.8	7/22	73.1	63.1	10.0	13
PTR-13	7/18/07	9/25/07	7/19	73.4	7/21	68.1	57.5	10.6	3
PTR-14	7/19/07	9/25/07	7/22	78.0	7/21	75.2	60.4	14.8	10

Temperature data was collected in 2008 as well by the Montana Department of Fish, Wildlife and Parks. "Water temperature was monitored at two sites on Peterson Creek from July 11 through October 13, 2008. The sites were located at RM 0.2 and 7.5 (near the confluence with Jack Creek). At RM 0.2, maximum daily temperatures exceeded 15°C (59°F) on 54 days, and 20°C (68°F) on 30 of those days. The maximum-recorded temperature at this site was 22.6°C (72.7°F) on August 18. At RM 7.5, water temperatures exceeded 15°C on 46 days, but on no days did they exceed 20°C. The maximum-recorded temperature at this site was 19.9°C (67.8°F) on July 26." (FWP, 2009).

6.3.2 Riparian Condition

Information within the DEQ Sufficient Credible Data/Beneficial Use Determination (SCD/BUD) (reference) file for the lower segment of Peterson Creek lists “Alteration in stream-side or littoral vegetation covers” as a probable cause for impairment, with Agriculture, Grazing in Riparian or Shoreline Zones, and Irrigated Crop Production as probable sources for that cause. While Alteration in stream-side vegetation covers is not, in itself, determined to be a pollutant that would require the development of a TMDL, there is a strong linkage between the riparian condition and the Temperature impairment listing, for which TMDL development is required. Information within the SCD/BUD file also notes that 4 miles above the mouth of the stream, cattle grazing and cultivated crops occur to the stream edge, and further downstream near the Deer Lodge city limit riparian removal and further riparian damage due to cattle/crop production exist.

The East Valley Watershed Baseline report (Kirk Environmental, 2003) also discusses riparian condition along Peterson Creek and the connection to stream temperatures. For that report, the Hansen Riparian Health Assessment was conducted on a number of streams including Peterson Creek and found that 36% of the stream riparian corridor was deemed “non-functional”, 59% “functional at risk”, and only 5% in “proper functioning condition”. A review of where these categories were applied to the stream found most all of Peterson Creek from Jack Creek to the mouth was considered “not-functional”.

The 2007 DEQ field effort collected riparian shade information for inclusion within the QUAL2K water quality temperature model of Peterson Creek, **Table 6-2**. Riparian shading was assessed at five sites along Peterson Creek using a Solar Pathfinder, which measures the amount of shade at a site in one-hour intervals. Comparisons of varying riparian shade conditions throughout the stream in relation to the vegetative communities that exist at a given site allow for assumptions on expected or “internal reference” conditions vs. disturbed conditions. Riparian shading data were used to assess existing and potential riparian shading conditions relative to the level of anthropogenic disturbance at a site. 2007 monitoring locations are presented in **Figure A-21**.

Average daily shade ranged from 34% at PTR-08 to 92% at PTR-07. The majority of the solar pathfinder measurements documented relatively dense shrub cover which was observed along much of Peterson Creek and measured at sites PTR-03, PTR-04 and PTR-07. Forested conditions in the headwaters were documented at the PTR-02 site, while open pasture conditions in areas of irrigated agriculture were documented at the PTR-08 site. PTR-04, PTR-07, and PTR-08 occur within the listed segment of Peterson Creek, while PTR-02 and PTR-03 occur in the upper segment.

Table 6-2. DEQ 2007 Shade Data

Temperature Data Logger Site	Stream	Site Description	Average Daily Shade	Average Azimuth	Average Bankfull Width (Feet)	Average Wetted Width (Feet)
PTR-02	Tributary 1	Conifers with graminoid understory, relatively narrow and flat valley, headwater tributary, grazed	71%	183%	7.8	4.7
PTR-03	Peterson Creek	Dense willow and alder in valley bottom, sparse cottonwoods, graminoid understory, influenced by beaver ponds, grazed	87%	39%	14.0	8.5

Table 6-2. DEQ 2007 Shade Data

Temperature Data Logger Site	Stream	Site Description	Average Daily Shade	Average Azimuth	Average Bankfull Width (Feet)	Average Wetted Width (Feet)
PTR-04	Peterson Creek	Alders, willow, sparse cottonwood, graminoid understory, conifers on hillslopes, grazed, evidence of pugging and hummocking	77%	33%	9.8	5.1
PTR-07	Peterson Creek	Willows with graminoid understory, entrenched gulch, grazed	92%	28%	8.0	6.9
PTR-08	Peterson Creek	Tall grass hayfield (with some interspersed streamside riparian shrub)	34%	23%	8.1	5.0

Following field data collection, a GIS project was initiated to evaluate riparian conditions along Peterson Creek using National Agricultural Imagery Program (NAIP) color aerial imagery from 2005, along with high-resolution color orthophotographs from May 20th, 2004 collected in the vicinity of Deer Lodge. A total of 10 reaches were delineated along Peterson Creek based on changes in vegetation type, changes in stream aspect, and tributary inputs. These 10 reaches were used to break Peterson Creek into 10 stream segments in the QUAL2K model. PCT5-PCT9 occur in the listed segment of Peterson Creek (**Table 6-3** and **Figure A-21**).

Table 6-3. Peterson Creek QUAL2K Temperature Model Reach Descriptions

Reach	Description
Mainstem headwater	The Mainstem Headwater Reach extended from the headwaters downstream to the confluence with Tributary 1. The data logger PTR-01 was located at the break between the Mainstem Headwater Reach and Reach PCT1. Vegetation included conifers in the overstory with shrubs in the understory.
PCT1	Reach PCT1 extended from Tributary 1 downstream to a road crossing that is associated with a slight aspect change as well as a change in riparian vegetation. Tributary 1 is apparently larger than Peterson Creek at the confluence. Vegetation included conifers in the overstory with shrubs in the understory.
PCT2	Reach PCT2 extends from the road crossing downstream past data logger PTR-03 to a change in vegetation. Tributary 2 and Tributary 3 enter this reach upstream of the PTR-03 data logger. Vegetation included shrubs in the valley bottom and conifers on the hillslopes. Beaver ponds were observed during the 2007 field assessment.
PCT3	Reach PCT3 extended from a vegetation break to an aspect break. There are no data loggers and no tributary inputs. Vegetation included sparse deciduous trees and shrubs in the valley bottom and conifers on the hillslopes.
PCT4	Reach PCT4 extended down to the confluence with Jack Creek. Vegetation includes deciduous trees and shrubs in the valley bottom and conifers on the hillslopes. This reach marked the lowest extend of coniferous vegetation.
PCT5	Reach PCT5 extended from the confluence with Jack Creek downstream to the upstream end of the hayfield and the start of irrigated agriculture. This reach included data logger PTR-07. Vegetation included shrubs in the valley bottom.
PCT6	Reach PCT6 included the irrigated hayfield through which this entire reach flows. Data logger PTR-09 was located in this reach along with the PTR-08 shade assessment site. Vegetation included open pasture and irrigated agriculture.

Table 6-3. Peterson Creek QUAL2K Temperature Model Reach Descriptions

Reach	Description
PCT7	Reach PCT7 began at the confluence with Burnt Hollow Creek which was smaller than Peterson Creek. Reach PCT7 flows through an area of irrigated agriculture and includes PTR-12. Vegetation included shrubs alternating with open pasture areas and sparse deciduous trees. Beaver dams were apparent in the 2004 aerial imagery.
PCT8	Reach PCT8 extended downstream from the I-90 crossing to where the channel became channelized along the east side of Deer Lodge. Vegetation included shrubs and sparse deciduous trees.
PCT9	Reach PCT 9 was channelized along the east side of Deer Lodge. Vegetation included shrubs and sparse deciduous trees alternative with open pasture areas.

6.3.3 Flow Conditions

Like riparian condition, flow conditions do have a linkage to temperature impairments, however flow alterations as a cause is not considered a pollutant that requires TMDL development. Never the less, information about the existing conditions related to flow may provide insight and contribute to the factors that influence temperature impairment.

The East Valley Watershed Baseline report mentions irrigation diversions throughout Peterson Creek are in need of repair, and as a result they divert water year round due to their condition. The opinion presented in that document states “Repair of the diversions is critical to restoring baseflow and spring runoff flows in this stream.” In lower reaches, flows ranged from 3.7 cfs in June, during runoff, to 0.1 cfs in September, during baseflow at P2 (approximately 1 mile from the mouth).

Flow measurements collected as part of the DEQ 2007 field monitoring effort in support of the QUAL2K model also describe considerably low flow conditions during the summer months. Streamflow was measured at 11 sites on Peterson Creek and selected tributary streams where temperature data logging devices were deployed. Streamflow data were collected during temperature data logger deployment (July 26-28, 2007) and again during retrieval (September 26, 2007). Results are presented in **Table 6-4**.

Table 6-4. 2007 Field Monitoring Location Flow Measurements

Temperature Data Logger Site	Stream	Deployment Flow (cfs)	Retrieval Flow (cfs)
PTR-01	Peterson Creek	0.1	0.02
PTR-02	Tributary 1, data invalid	0.6	0.05
PTR-03	Peterson Creek	1.6	0.3
PTR-04	Peterson Creek, data logger lost	1.7	0.2
PTR-05	Jack Creek	0.6	0.1
PTR-07	Peterson Creek	1.7	0.3
PTR-08 (no data logger)	Peterson Creek	2.0	0.3
PTR-09	Peterson Creek	N/A	N/A
PTR-11	Burnt Hollow Creek	0.1	N/A
PTR-12	Peterson Creek	2.1	0.3
PTR-13	Peterson Creek	0.6	N/A
PTR-14	Peterson Creek	0.4	0.1

N/A = no water present at time of monitoring

6.4 Water Quality Modeling using QUAL2K for Source Assessment

While currently available data seems to suggest elevated stream temperatures in Peterson Creek, a QUAL2K water quality model was used to determine if the temperature increases are the result of anthropogenic activities, and to simulate the potential effects of changes in the watershed and their impact on water temperature. The results of which help determine if human caused disturbances within the watershed have increased the water temperature above the “naturally occurring” level and, if so, to what degree. The model incorporated real temperature, flow, and shade information collected in the 2007 field season which was used to calibrate the model to best represent existing condition. Additionally, various scenarios that represent conditions absent of anthropogenic influence, as well as thermal restoration approaches in the watershed, were applied within the model to determine targeted temperature conditions. The full description of the model and results can be found in **Appendix G**. The following presents a summary of the considerations and findings from the modeling effort.

6.4.1 Conditions and Assumptions

The data provided does ground the model in reality, however as with any modeling exercise, resources, time, and level of detail prohibit an unlimited data set from which to refine the model. Due to these constraints and the complexity of environmental systems, a number of assumptions must be made. Assumptions incorporated into the Peterson Creek temperature model include:

1. Temperature data loggers were placed at 11 sites in the Peterson Creek watershed during the summer of 2007, including eight mainstem locations and three tributaries. The maximum daily temperature and the maximum 7-day average maximum temperature data were reviewed to identify the warmest period of the season. Maximum daily temperatures occurred between July 19th and 28th, while the maximum 7-day average

maximum temperature occurred between July 20th and 22nd (variability depended upon the location). Based on this data set, the QUAL2K model was run for temperature data associated with July 21st, 2007 to evaluate temperature flux and changes that may occur under "worst case" conditions.

2. Streamflow data were collected at 11 sites during temperature data logger deployment and retrieval. Streamflows collected during data logger deployment were applied in the QUAL2K model since the deployment date (July 16th –18th) was near the date for which maximum temperatures were modeled (July 21st).

3. Streamside shading was assessed at five sites corresponding to the location of temperature data loggers. Four sites were located on Peterson Creek, while one site was located on a headwater tributary stream. Riparian shade was assessed using a solar pathfinder, which measures the amount of shade in a day, at one-hour intervals. The majority of the solar pathfinder measurements documented relatively dense shrub cover which was observed along much of Peterson Creek and measured at sites PTR-03, PTR-04 and PTR-07. Forested conditions in the headwaters were documented at the PTR-02 site, while open pasture conditions in areas of irrigated agriculture were documented at the PTR-08 site.

4. Following field data collection, a GIS project was initiated to evaluate riparian conditions along Peterson Creek, and to delineate the stream into appropriate reaches to represent the varied conditions in the QUAL2K model. A total of 10 reaches were delineated along Peterson Creek based on changes in vegetation type, changes in stream aspect, and tributary inputs. (**Figure A-21**)

   Solar pathfinder data collected at five sites in the Peterson Creek watershed were used to assign shading values to assessed reaches in the QUAL2K model. For reaches in which no solar pathfinder data were collected, shade values were extrapolated from assessed reaches based on similar riparian vegetation characteristics as observed in GIS (**Table 6-5**).

Table 6-5. Solar Pathfinder Shade Data Applied in QUAL2K.

Reach	QUAL2K Reach Identifier	Solar Pathfinder Measurement Performed	Solar Pathfinder Measurement Applied
1	Mainstem headwater	No	PTR-02
2	PCT1	No	PTR-02
3	PCT2	PTR-03	PTR-03
4	PCT3	No	PTR-04
5	PCT4	PTR-04	PTR-04
6	PCT5	PTR-07	PTR-07/08
7	PCT6	PTR-08	PTR-08
8	PCT7	No	PTR-07/08
9	PCT8	No	PTR-07/08
10	PCT9	No	PTR-08

5. To evaluate tributary and ground water inputs and water withdrawals along Peterson Creek, a hydrologic balance was created. Flows were balanced at the outlet of each reach and at each data logger site where flows were measured. Where tributaries were present in a reach, increases in streamflow were entirely attributed to the tributary inflows. When no tributaries were present, inputs were attributed to ground water discharge in the upper watershed and to irrigation return flows in the lower watershed. Streamflow decreases were considered due to irrigation withdrawals, which are evident in the aerial imagery.

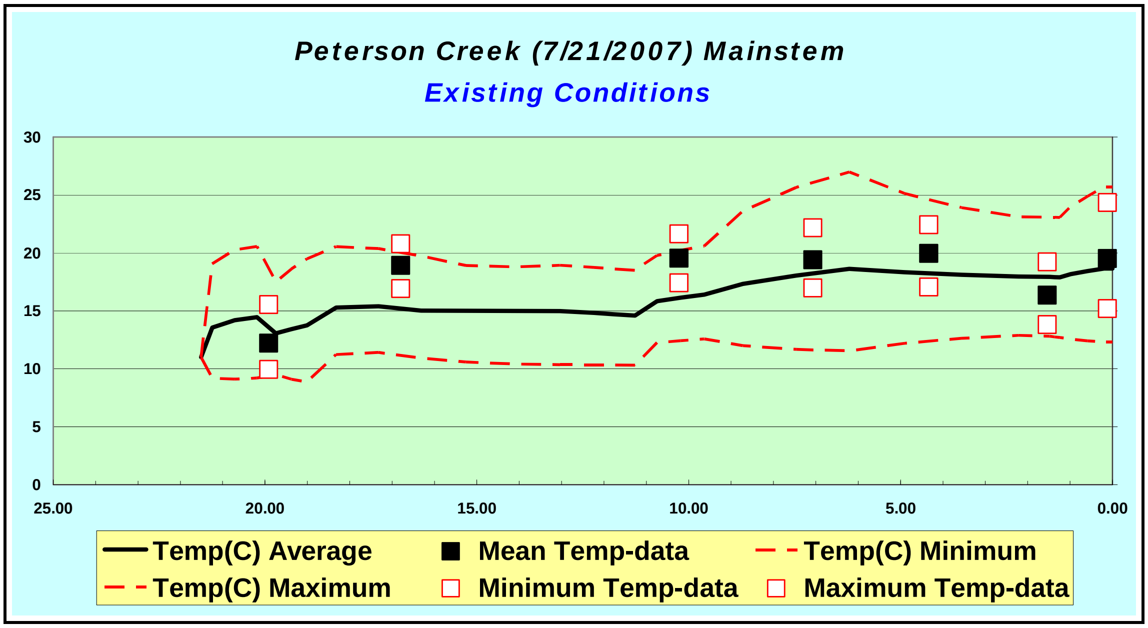
   Once the conditions and assumptions were set in the model, a number of different scenarios were run to simulate existing conditions, as well as the potential outcomes from changes in watershed condition. Descriptions of these scenarios follow.

6.4.2 Existing Condition Scenario

The QUAL2K model was run for the baseline scenario which is intended to represent existing conditions in Peterson Creek on July 21st, 2007 (**Figure 6-1**). This model run utilized all measured field data, and incorporated all assumptions as described above. The baseline model scenario was unable to precisely recreate the field observed temperature values. However temperature fluctuation trends from upstream to downstream were reasonably matched indicating that while the temperature values derived in the model may not be entirely accurate in comparison to the field measured data, the factors effecting the stream from upstream to downstream do appear to be adequately represented. Poor model calibration between sites PTR-01 and PTR-03 was thought to be primarily due to the small size of this stream relative to the influence of riparian shading, and difficulties in calibrating overall were also attributed to limitations of modeling a stream with such small flow. However, hydraulic output in the model accurately reflected measured conditions, indicating that water routing and channel morphology were adequately calibrated.

Table 6-6. Field Data and Modeled Existing Condition Temperature Comparisons

Data Logger Site	2007 Field Data	QUAL2K Existing Conditions	Departure From 2007 Field Data
	Maximum Temperature (°F)	Maximum Temperature (°F)	
PTR-01	60	63.5	3.53
PTR-03	69.4	67.5	-1.89
PTR-07	71	68.4	-2.54
PTR-09	71.9	78.2	6.23
PTR-12	72.4	77.3	4.86
PTR-13	66.6	73.6	6.97
PTR-14	75.8	78.3	2.43



Point measurements progressing downstream: PTR-01, PTR-03, PTR-07, PTR-09, PTR-12, PTR-13, and PTR-14. Jack Creek confluence above PTR-07. Burnt Hollow Creek above PTR-12. I-90 crossing at PTR-13.

Figure 6-1. QUAL2K Baseline (Existing Conditions) Scenario.

The baseline scenario model run indicated that stream temperatures remained relatively cool downstream to the confluence with Jack Creek and the PTR-07 data logger. In contrast, actual temperature measurements in 2007 indicated water temperature increases near the PTR-03 data logger followed by relatively constant temperatures progressing downstream all the way to the mouth. Modeled stream temperatures increased between Jack Creek and Burnt Hollow Creek, followed by downstream temperatures decreases. The maximum measured temperature was recorded at the PTR-12 data logger, which was located downstream of the confluence with Burnt Hollow Creek. Both the modeled and measured temperatures decreased as Peterson Creek approached the I-90 crossing. This may have been due to what appeared to be a large beaver complex within reach PCT7. Downstream of the I-90 crossing, both modeled and measured temperatures again increased. Thus, the results of the baseline modeling effort and 2007 field temperature measurements indicated that Peterson Creek from the Jack Creek confluence and continuing downstream past Burnt Hollow Creek, and Peterson Creek downstream of the I-90 crossing, may be negatively influenced by elevated water temperatures.

6.4.3 Shade Scenarios

In the shade modeling scenario, areas with presently diminished shade conditions (PCT5-PCT9) were changed to an unperturbed reference condition of 86%, based on field measured shade values from PCT3, PCT4, and PCT7. All other parameters from the baseline scenario were retained. The results of shade scenario 1 indicated a dramatic decrease in maximum temperatures, particularly in reaches PCT6 and PCT9 which were generally lacking woody shrub cover (**Table 6-7**). The dramatic modeled temperature reductions were likely influenced by the minimal flow and associated small buffering capacity of this small stream.

Table 6-7. Modeled Shade Condition (v.1) Temperature Comparison

Data Logger Site	QUAL2K Existing Conditions	QUAL2K Shade 1 Conditions	Departure From Existing Conditions Model
	Maximum Temperature (°F)	Maximum Temperature (°F)	
PTR-01	63.5	63.5	0
PTR-03	67.5	67.5	0
PTR-07	68.4	66.7	**-1.7**
PTR-09	78.2	65.4	**-12.8**
PTR-12	77.3	64.9	**-12.4**
PTR-13	73.6	65.2	**-8.4**
PTR-14	78.3	64.9	**-13.4**

Bold text indicates violation of Montana's water quality standard

To further evaluate the influence of shade, a second scenario was assessed in which the estimated reference value was applied only to reaches PCT6 and PCT9, which are the two reaches that have the most apparent alteration to riparian condition, and the most likely areas for potential improvement. These two reaches had extensive areas of open pasture and minimal riparian shrub cover as observed on aerial imagery from 2004 and 2005. All other parameters from the baseline scenario were retained. The second shade scenario also led to a substantial decrease in maximum temperatures (**Table 6-8**). Due to the more realistic potential for improvement in these specific reaches, this scenario was determined to best represent the potential to decrease stream temperatures by increasing shade along selected reaches of Peterson Creek.

Table 6-8. Modeled Shade Condition (v.2) Temperature Comparison

Data Logger Site	QUAL2K Existing Conditions	QUAL2K Shade 2 Conditions	Departure From Existing Conditions Model
	Maximum Temperature (°F)	Maximum Temperature (°F)	
PTR-01	63.5	63.5	0
PTR-03	67.5	67.5	0
PTR-07	68.4	68.4	0
PTR-09	78.2	66.9	**-11.3**
PTR-12	77.3	67.7	**-9.6**
PTR-13	73.6	70.3	**-3.3**
PTR-14	78.3	68.6	**-9.7**

Bold text indicates violation of Montana's water quality standard

6.4.4 Water Consumptive Use Scenario

The water consumptive use scenario describes the thermal effect of irrigation and domestic water uses on water temperatures in Peterson Creek. This scenario was modeled by removing existing water diversions from the study reach as identified in the hydrologic balance (thereby resulting in a modeled gain of 0.26 cfs). All other parameters from the baseline scenario were retained. This scenario indicated that water withdrawals have a lesser potential impact on stream temperatures than riparian shading (**Table 6-9**). The model indicated that slight decreases in temperature could be achieved through water conservation in reach PCT6 upstream of the confluence with Burnt Hollow Creek and reach PCT9 through the City of Deer Lodge. Due to a lack of measurements of irrigation withdrawals throughout the system, the results of the water consumptive use scenario should be interpreted with caution. For example, note that streamflow measurements in July of 2007 document a maximum flow in Peterson Creek of 2.1 cfs at site PTR-12, with flows then decreasing to 0.4 cfs by the mouth (site PTR-14), which is a distance of approximately 2.6 miles. This indicates what may be a more significant effect from irrigation withdrawls than was able to be simulated in the model with the available data. If more detailed flow data for the irrigation network becomes available, this scenario may need to be reevaluated.

This section of Peterson Creek may be an appropriate area on which to focus water management activities since flows were observed to decrease by 80% in this reach, which extends from downstream of the confluence with Burnt Hollow Creek to the mouth.

Table 6-9. Modeled Water Use Temperature Scenario

Data Logger Site	QUAL2K Existing Conditions	QUAL2K Water Use Conditions	Departure From Existing Conditions Model
	Maximum Temperature (°F)	Maximum Temperature (°F)	
PTR-01	63.5	63.5	0
PTR-03	67.5	67.5	0
PTR-07	68.4	68.5	0.1
PTR-09	78.2	77.5	**-0.7**
PTR-12	77.3	77.5	0.2
PTR-13	73.6	74.3	0.7
PTR-14	78.3	76.7	**-1.6**

Bold text indicates violation of Montana’s water quality standard

6.4.5 Channel Morphology Scenario

When applying the QUAL2K model in temperature assessments, a channel morphology scenario that examines the influence of channel over-widening is often applied. However, field data collected in 2007 documented low width/depth ratios, suggesting there was minimal potential to further reduce stream channel width. Thus, the channel morphology modeling scenario was not applied to the Peterson Creek temperature assessment.

6.4.6 Natural Condition Scenario

The natural condition scenario reflects the temperature regime that would be expected absent of the influence of man. This allows for the characterization of the extent of the departure from the natural condition. Factors applied in shade scenario 1 (reference shade) and the water consumptive use scenario (no irrigation withdrawals) were applied to run this scenario. All other parameters from the baseline scenario were retained. The natural condition scenario indicated that maximum temperatures at the mouth of Peterson Creek could be approximately 15°F cooler than the modeled maximum temperature of 78.3°F (**Table 6-10**). The measured maximum temperature on July 21st of 2007 was 75.8°F at the mouth (PTR-14), while the natural condition scenario results in a maximum temperature of 62.7°F, suggesting water temperatures could be approximately 13°F cooler at the mouth of Peterson Creek. The seasonal maximum value at site PTR-14 was 78.0°F on July 22nd.

Table 6-10. Modeled Natural Condition Temperature Comparison

Data Logger Site	QUAL2K Existing Conditions	QUAL2K Natural Conditions	Departure From Existing Conditions Model
	Maximum Temperature (°F)	Maximum Temperature (°F)	
PTR-01	63.5	63.5	0
PTR-03	67.5	67.5	0
PTR-07	68.4	66.5	**-1.9**
PTR-09	78.2	64.6	**-13.6**
PTR-12	77.3	63.7	**-13.6**
PTR-13	73.6	63	**-10.6**
PTR-14	78.3	62.7	**-15.6**

Bold text indicates violation of Montana's water quality standard

6.4.7 Naturally Occurring Scenario (ARM 17.30.602)

The naturally occurring scenario defines water temperature conditions resulting from the implementation of all reasonable land, soil and water conservation practices as outlined in ARM 17.30.602. This scenario identifies the "naturally occurring" temperature in water bodies of interest and establishes the temperatures to which a 0.5°F (0.23°C) temperature increase is allowable. This, in turn, can be used to identify the impairment status of a water body. This scenario included improved shading in reaches PCT6 and PCT9 as suggested by shade scenario 2 along with a 15% increase in irrigation and domestic water use efficiency. This was calculated by reducing the three identified irrigation withdrawals by 15%. The result of the naturally occurring scenario was similar to the result of shade scenario 2, with substantial reductions in temperature predicted in Peterson Creek downstream of the confluence with Jack Creek. Based on the naturally occurring scenario, a maximum temperature of 68.6°F was predicted at the mouth of Peterson Creek and there is the potential for an approximately 10°F reduction in in-stream temperatures relative to the baseline scenario. It should be noted however, that the assumptions for Shade scenario 2, and the Naturally Occuring scenario which incorporates shade scenario 2, confine the shading improvements to reaches PCT6 and PCT9 because these two reaches were identified as the most appropriate for potential improvement and the most likely to represent the potential changes that could occur in improving shade throughout Peterson Creek. It does not, however, absolutely preclude the potential for improvement in other reaches of Peterson Creek, or imply that no other reaches could benefit from potential shade improvement, or that all other reaches are currently in a true "naturally occurring" scenario. As evidenced in shade scenario 1, a 1.7°F reduction in temperature was modeled at PTR07, which is located within reach PTR5 and therefore would imply that potential improvement could occur there as well. However, due to the uncertainties and inaccuracies associated with using a model, the decision was made to represent the shade improvement and resulting temperatures decreases to those reaches clearly identified and understood as affected by anthropogenic change.

Table 6-11. Modeled Naturally Occuring Temperature Comparison

Data Logger Site	QUAL2K Existing Conditions	QUAL2K Naturally Occurring Conditions	Departure From Existing Conditions Model
	Maximum Temperature (°F)	Maximum Temperature (°F)	
PTR-01	63.5	63.5	0
PTR-03	67.5	67.5	0
PTR-07	68.4	68.4	0
PTR-09	78.2	66.9	**-11.21**
PTR-12	77.3	67.6	**-9.61**
PTR-13	73.6	70.1	**-3.47**
PTR-14	78.3	68.6	**-9.72**

Bold text indicates violation of Montana's water quality standard

6.4.8 Peterson Creek Modeled Temperature Relative to Montana Standards

The naturally occurring scenario indicated that water temperatures greater than 66.5°F can be expected in Peterson Creek. Thus, the maximum allowable increase in temperature due to unmitigated human causes is 0.5°F (0.23°C). This standard was exceeded at the lower-most four monitoring sites on Peterson Creek, which represents Peterson Creek from downstream of Jack Creek to the confluence with the Clark Fork River (**Table 6-12**). The majority of the temperature reduction potential predicted by the QUAL2K model resulted from increased shade, as presented in shade scenario 2, with an additional smaller reduction in temperatures resulting from improved irrigation and domestic water management. As discussed in **Section 6.4.2**, the dramatic modeled temperature reductions were likely a result of the minimal flow in this small stream. Due to the minimal amount of flow, there may be a substantial amount of error in the QUAL2K model. However, temperature data collected in 2007 and the results of this QUAL2K modeling effort suggest that Peterson Creek fails to meet Montana's standard for temperature during low flow periods in the middle of summer and that an increase in riparian shading, particularly along reaches PCT6 and PCT9 will likely lead to a decrease in water temperatures.

Table 6-12. Peterson Creek Temperatures Relative to Montana's Water Quality Standards.

Data Logger Site	Field Measured Data	QUAL2K Existing Conditions	Departure from Field Data (ºF)	QUAL2K Naturally Occurring Scenario	Departure from Existing Conditions Model (ºF)
	Maximum Temperature (ºF)	Maximum Temperature (ºF)		Maximum Temperature (ºF)	
PTR-01	60.0	63.5	3.53	63.5	0.00
PTR-03	69.4	67.5	-1.89	67.5	0.00
PTR-07	71.0	68.4	-2.54	68.4	0.00
PTR-09	71.9	78.2	6.23	66.9	**-11.21**
PTR-12	72.4	77.3	4.86	67.6	**-9.61**
PTR-13	66.6	73.6	6.97	70.1	**-3.47**
PTR-14	75.8	78.3	2.43	68.6	**-9.72**

Bold text indicates violation of Montana's water quality standard

6.5 Peterson Creek Thermal Water Quality Status Summary

Currently available data has shown temperature values above 66.5°F. QUAL2K model scenarios also suggest that under naturally occurring conditions, some areas of Peterson Creek may exceed 66.5°F. The model strongly suggests human influenced temperature increases in Peterson Creek well above the allowable 0.5°F. Currently available data, coupled with QUAL2K modeling results, indicate that loss of stream shade through anthropogenic influence on the riparian corridor, as well as irrigation infrastructure inefficiencies, both in combination or when either is considered as a single source, has raised water temperatures in Peterson Creek above the state temperature standard during the warmest months of the year and justify the need for a TMDL.

6.6 Temperature Targets

Montana's water quality standard for temperature specifies a maximum allowable increase above the "naturally occurring" temperature in order to protect the existing thermal regime for fish and aquatic life. For waters classified as B-1, the maximum allowable increase over the naturally occurring temperature is 1°F, if the naturally occurring temperature is less than 66º Fahrenheit. Within the naturally occurring temperature range of 66-66.5 ºF, the allowable increase cannot exceed 67ºF. If the naturally occurring temperature is greater than 66.5ºF, the maximum allowable increase is 0.5º F [ARM 17.30.622(e) and ARM 17.30.623(e)]. In-stream temperature monitoring and predictive modeling both indicate that naturally occurring stream temperatures in Peterson Creek are likely greater than 66.5°F during portions of the summer months. Based on this analysis, the maximum allowable increase due to unmitigated human causes would be 0.5°F (0.23°C).

Water temperature, flow, and riparian shade data collected in the summer of 2007 were incorporated within a QUAL2K water quality model (**Appendix G**) to assess existing water temperatures in Peterson Creek. Modeling is used to determine if human caused disturbances within the watershed increase the water temperature above the "naturally occurring" level and, if so, to what degree. The potential to reduce stream temperatures through management measures was also modeled based on varied scenarios.

Model results from an existing condition scenario and a scenario simulating reasonable land, soil and water conservation practices were used to assess existing and potential water temperature conditions in Peterson Creek relative to Montana's water quality standards. The difference in temperatures is used to indicate if Montana's water quality temperature standard is likely being met or exceeded. The relationship between anthropogenic disturbances and water temperature impairments as described in ARM 17.30.623(e) was evaluated as described below and provides justification for the resultant temperature targets:

> If simulated stream temperatures derived from the QUAL2K model using the "existing conditions" data deviated by <u>less than 0.5ºF</u> from stream temperatures derived using the "potential conditions" data when all reasonable land, soil and water conservation practices were applied, then anthropogenic sources were concluded to not be causing or contributing to violations of the relevant B-1 water temperature standards and the stream

> was not considered to be impaired due to anthropogenic (or anthropogenically induced) thermal modifications.
>
> If simulated stream temperatures derived from the QUAL2K model using the "existing conditions" data deviated by greater than 0.5ºF from stream temperatures derived using the " potential conditions" data when all reasonable land, soil and water conservation practices were applied, then anthropogenic sources were concluded to be causing or contributing to violations of the relevant B-1 water temperature standards and the stream was considered to be impaired due to anthropogenic thermal modifications.

6.6.1 Targets

Modeling uses real data to simulate watershed conditions and potential water quality outcomes, however no model can ever fully simulate all the dynamic and complex factors that affect water quality without the inclusion of some assumption and some error. Due to the difficulty in the ability of these tools to definitively assess the ability to attain the state standards, the targets also incorporate an "or" statement, with Montana's temperature standard presented as the primary target that needs to be satisfied. Compliance with the primary target could ultimately be shown via additional monitoring and improved modeling after implementation of necessary reasonable practices.

Alternatively, compliance with standards can be satisfied by meeting the "or" statement targets; those conditions of shade and flow that define naturally occurring. In this approach, if all reasonable land, soil, and water conservation practices are installed, state standards are met. However, if it is found that the state temperature standards are met, the use is supported, and therefore not all areas may need to have full implementation of restoration practices to meet the standards since a 0.5 degree allowance is incorporated. These "or" conditions are referred to here as restoration targets (**Table 6-13**).

Table 6-13. Targets for Temperature in Peterson Creek.

Water Quality Targets	Criteria
Maximum allowable increase over naturally occurring temperature	For waters classified as B-1, a 1ºF maximum increase above naturally occurring water temperature is allowed within the range of 32ºF to 66ºF; within the naturally occurring range of 66ºF to 66.5ºF, no discharge is allowed which will cause the water temperature to exceed 67ºF; and where the naturally occurring water temperature is 66.5ºF or greater, the maximum allowable increase in water temperature is 0.5ºF.
OR meet ALL of the temperature influencing restoration targets below	
Riparian Shade	Peterson Creek between Jack Creek and mouth: average daily shade 85% as measured using Solar Pathfinder, with specific focus from Jack Creek to Burnt Hollow Creek, and Boulder Road to the mouth.
Channel width/depth ratio	No preventable human caused increases in width/depth ratios throughout Peterson Creek.
Irrigation water management	15% improvement in irrigation efficiency during the warmest months (mid-June through August).
Inflows to stream	No human caused surface water inflow, in single or in combination, will increase temperatures more than the allowable temperatures as described in the standard.

6.6.1.1 Riparian Canopy Density

Shade provided by riparian vegetation decreases the amount of solar radiation reaching the channel and buffers stream temperature fluctuations. Based on the Peterson Creek watershed temperature modeling effort, riparian shade appears to be the most significant factor influencing stream temperatures. Previous studies in the area have shown limited riparian quality and considerable potential for improvement through much of the stream corridor between Jack Creek and the mouth of Peterson Creek. Further upstream, riparian communities appear to exist in a more natural condition and are represented by thick shrub, cottonwood, and conifer communities. These types of vegetative communities can be expected throughout the entire Peterson Creek corridor although they do appear in some isolated stretches throughout the lower watershed. The 85% average daily shade surrogate target is based on the average of three Solar Pathfinder shade measurements on Peterson Creek – two of which were located in the upper reaches of the watershed, and one in a more natural riparian environment in the lower reach.

6.6.1.2 Width/Depth Ratio

Lower channel width-to-depth ratios are associated with the presence of deep pools and runs that resist daily fluctuations in stream temperature and provide better thermal protection for cold water fish (Riggers et al.1998). A decrease in depth tends to reduce the number of pools (Beschta and Platts 1986), while an increase in width allows a greater surface area to be affected by inputs of solar radiation, which can lead to higher stream temperatures. Also, a narrower channel receives increased shade from a constant sized riparian canopy when compared to a wider channel. Thermal refuges provided by deep pools and overhead cover of riparian vegetation are essential for salmonids, which use pools for thermal refugia in the summer (Lamothe and Magee 2003), as well as for over-wintering habitat (West et al. 1992). Stream channel morphology data collected in the summer of 2007 documented low width/depth ratios, suggesting there was little potential to further reduce stream channel width, and little influence of the current stream channel sizes on the overall temperature trends in Peterson Creek. Maintaining existing stream channel morphology will assist in limiting future and greater temperature increases throughout the stream.

6.6.1.3 Irrigation Water Management

Streamflow depletion due to irrigation withdrawals can lead to increased water temperatures since a lesser volume of generally shallower water will heat up more quickly from incoming solar radiation. Greater daily fluctuations in temperature can also be expected when flows are low. In addition to increased stream temperatures that can result from dewatering, irrigation return flows may be warmer than natural streams and may further contribute to increased water temperatures. Impacts of irrigation network efficiencies on Peterson Creek are not very well identified however the QUAL2K modeling effort showed slight decreases in temperature could be achieved through water conservation in the reach upstream of the confluence of Burnt Hollow Creek and the lower reaches through the city of Deer Lodge. The East Valley Watershed Report completed in 2003 also noted that the irrigation diversions throughout Peterson Creek are in need of repair, and as a result they divert water year round due to their condition. Due to the importance of instream flows on temperature, and based on findings in the Big Hole watershed regarding reasonable irrigation efficiency improvement potential, a 15 percent improvement in irrigation efficiency during the warmest months of the year (July-Mid September) is recommended as an indirect water quality target for water temperature impairments. In addition, human induced surface water return flows, in single or in combination, should not increase temperatures above Montana standards, and potential improvements in improved irrigation management during the hottest periods of the year should be investigated.

6.7 Temperature TMDL and Allocations

Total maximum daily loads (TMDLs) are a measure of the maximum load of a pollutant a particular water body can assimilate and still maintain water quality standards. A TMDL is the sum of waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources, and includes a margin of safety (MOS) that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving stream (**Equation 6-1**). Allocations represent the distribution of allowable load applied to those factors that influence loading to the stream. In the case of temperature, thermal loading is assessed.

Equation 6-1. $\text{TMDL} = \Sigma\text{WLA} + \Sigma\text{LA} + \text{MOS}$.

Where:

ΣWLA = Waste Load Allocation = Pollutants from NPDES Point Sources
ΣLA = Load Allocation = Pollutants from Nonpoint Sources + Natural Sources
MOS = Margin of Safety

For temperature TMDLs, because of the dynamic temperature conditions throughout the course of a day, the TMDL is the thermal load, at any instantaneous moment, associated with the stream temperature when in compliance with Montana’s water quality standards. As stated earlier, the temperature standard for Peterson Creek is defined as follows: For waters classified as B-1, the maximum allowable increase over the naturally occurring temperature is 1°F, if the naturally occurring temperature is less than 66º Fahrenheit. Within the naturally occurring temperature range of 66-66.5 ºF, the allowable increase cannot exceed 67ºF. If the naturally occurring temperature is greater than 66.5ºF, the maximum allowable increase is 0.5º F [ARM 17.30.622(e) and ARM 17.30.623(e)]. Montana’s temperature standard for B1 classified waters is depicted in **Figure 6-2**.

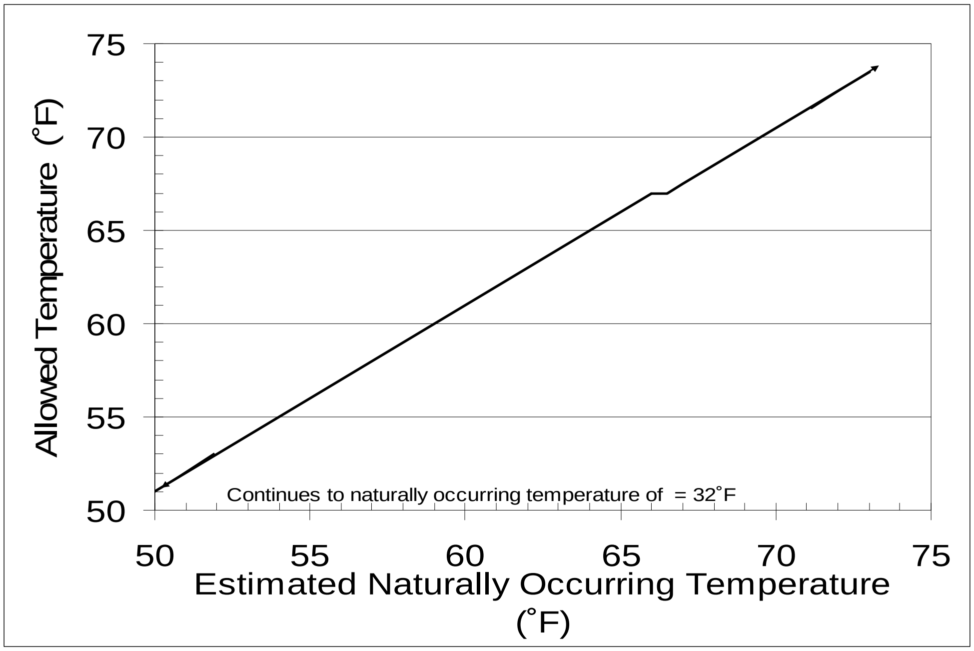


Figure 6-2. In-Stream Temperatures Allowed by Montana's B-1 Classification Temperature Standard

The instantaneous load is computed by the second. The allowed temperature can be calculated using Montana’s B1 classification temperature standards (**Figure 6-2**) and using a modeled, measured, or estimated naturally occurring instantaneous temperature. The instantaneous total maximum load (per second) at any location in the water body is provided **Equation 6-2**. The allowable loading over a second is expressed as the allowable loading to the liquid form of the water in the stream. This is defined as the kCal increase associated with the warming of the water from 32°F to the temperature that represents compliance with Montana's temperature standard as determined from **Figure 6-3**.

Equation 6-2

$(\Delta-32)*(Q)*(15.7)$ = Instantaneous Thermal Load (ITL)

Where:

Δ = allowed temperatures from **Figure 6-2**
Q = instantaneous discharge in CFS
ITL = Allowed thermal load per second in kilocalories per day above waters melting point
Conversion factor = 15.7

While the above equation and translation of temperature to an instantaneous thermal load allows for a quantitative expression by which to compare to Montana’s state standard and accurately define a thermal load, in practical terms this is not readily translatable to on-the-ground management or allocation of load among contributing sources. Alternatively then, the TMDL may be expressed as the thermal load associated with stream temperatures when surrogates for the load expression are met that would result in the compliance with state standards. In this case, the allocations necessary to achieve the TMDL are similar to the restoration targets by which to measure achievement of the state temperature standard. Namely, an increase in riparian shade conditions to 85% shade in reaches PCT 6 and PCT 9, and a 15% improvement in irrigation efficiencies. These allocations are applied to all anthropogenic related agricultural and/or streamside activities throughout Peterson Creek stream corridor.

Table 6-14. TMDL for Temperature in Peterson Creek.

The TMDL equals the resultant thermal load associated with stream temperature when all conditions below are met:	
Source Type	**Load Allocation (surrogate)**
Agricultural activities and other land uses that could impact riparian health and resultant shade provided by the riparian or near stream vegetation.	Peterson Creek between Jack Creek and mouth: the thermal load that can reach the stream when there is an average daily shade of 85% using a Solar Pathfinder, with specific focus from Jack Creek to Burnt Hollow Creek, and Boulder Road to the mouth.
Agricultural activities or other land uses that could impact Channel width/depth ratio	No measurable increase in thermal loading to the stream from preventable human caused increases in width/depth ratios throughout Peterson Creek.

Modeling results provided much of the technical framework for developing a surrogate-based temperature TMDL and allocation approach. Influences to instream temperatures are not always intuitive at a watershed scale and the modeling effort helped estimate the relative effects that stream shading, channel geometry, and stream flow have on stream temperature during the hottest time of year.

The restoration targets necessary to meet the TMDL include two primary approaches to reduce thermal loading:

- Restoring riparian cover over the creek to achieve a consistent and contiguous naturally occurring canopy, applied to the sources that are currently limiting shade.
    - *Human Influences:* Almost all of the impact to riparian canopy cover is due to present or historic agricultural activities.
    - *Link to thermal conditions*:
      More shading reduces sunlight, and thus heat, entering the stream.
      Riparian vegetation creates a microclimate that is cooler than the surrounding landscape.
- Maintain reasonable stream morphology including bankfull width to depth ratios of Peterson Creek.
    - *Human Influences*: Based on currently available data, width to depth ratios in Peterson Creek currently indicate relatively stable stream channel conditions, however destabilization of stream banks and subsequent widening of the stream from over grazing or riparian vegetation clearing can also lead to elevated stream temperatures. Current conditions should be maintained or improved in those areas where appropriate.
    - *Link to thermal conditions*:

Lower width to depth ratio equates to a deeper, narrower channel that has small contact area with warm afternoon air.

Lower width to depth ratio will increase the effectiveness of shading produced by the riparian canopy.

Additionally, water management options and irrigation efficiency improvements should be investigated and incorporated into the overall restoration strategy as discussed in **Section 9.0**. While state and federal water quality laws state that TMDL cannot divest, impair, or harm legal water rights and appropriations, the linkage between water volume and temperature, and the fact that opportunities normally exist to conserve water should not be ignored. Increases in available water will result in increased assimilative capacity of thermal load and aid in the reduction of water temperatures. Two additional approaches to reduce thermal loading include:

- Increase instream flow volume due to voluntary reasonable irrigation water management practices and water leasing system that fit into existing water right framework.
    - *Human Influences*: All of the impact to reduced stream flow is due to agricultural activities.
    - *Link to thermal conditions*:
      Increased water volume can attenuate a given thermal load to a lower temperature than a lesser volume of water.
      More water in the stream channel decreases the surface area to water volume ratio. A decreased surface to volume ratio decreases the attenuation capacity of the stream.
- Reduction in warm water irrigation return flows via adaptive management approach.
    - *Human Influences*: Return flows may result from the agricultural irrigation system.
    - *Link to thermal conditions*:
      Increased thermal load

Thermal conditions within Peterson Creek are largely the result of complex interactions among the factors outlined above, which prevents an easy interpretation of the influence of each one separate from the others. Modeling results indicate that shade from riparian vegetation, as well as stream flow volume is affecting temperature in Peterson Creek. If allocations and associated restoration strategies are met in combination, they will achieve Montana's temperature standards. All thermal load reductions resulting from the Load Allocation approach are allocated to agricultural activities and can be achieved by applying reasonable land, soil, and water conservation practices.

6.8 Margin of Safety and Seasonal Considerations

All TMDL/Water Quality Restoration Planning documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream, and load allocations. TMDL development must also incorporate a margin of safety into the allocation process to account for uncertainties in pollutant sources and other watershed conditions, and ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes, in detail, considerations of seasonality and a margin of safety in the temperature TMDL development process.

The margin of safety is addressed in several ways as part of this document:

- Montana’s water quality standards are applicable to any timeframe and any season. The temperature modeling analysis investigated temperature conditions during the heat of the summer when the temperature standards are most likely exceeded.
- Montana has also built an inherent margin of safety into Montana’s temperature standards. In effect, Montana’s standard for B1 streams incorporates a combined load allocation and wasteload allocation equal to 0.5-1°F depending on naturally occurring temperature conditions at any time of the year. This small shift in allowed temperature increase will protect all beneficial uses in Peterson Creek and should equate to cooler water if the load reduction approaches provided in this document are followed.
- The margin of safety considerations for the thermal surrogate TMDL apply an implicit safety factor, because if they are fully achieved, would reduce temperatures to naturally occurring levels without the standards consideration of 0.5°F or 1°F heating above naturally occurring temperatures.
- The assessment and subsequent allocation scenarios addressed instream flows that affect the streams dissipative capacity to absorb heat.
- Compliance with targets and refinement of load allocations are all based on an adaptive management approach (**Section 6.9, 6.10**) that relies on future monitoring and assessment for updating planning and implementation efforts.

Seasonal considerations are significant for temperature. Obviously, with high temperatures being a primary limiting factor for westlope cutthroat and other coldwater fish in Peterson Creek, summer temperatures are a paramount concern. Therefore, focusing on summer thermal regime is an appropriate approach. Seasonality addresses the need to ensure year round beneficial use support. Seasonality is addressed in this TMDL document as follows:

- Temperature monitoring occurred during the summer season, which is the warmest time of the year. Modeling simulated heat of the summer conditions when instream temperatures are most stressful to the fishery. The fishery is the most sensitive use in regard to thermal conditions.
- Temperature targets apply year round, but are most applicable to summer conditions.
- Restoration approaches will help to stabilize stream temperatures year round.

SECTION 7.0
METALS TMDL COMPONENTS

This portion of the document focuses on metals as an identified cause of water quality impairments in the Upper Clark Fork TPA. It describes: 1) the mechanisms by which metals impair beneficial uses of those streams, 2) the specific stream segments of concern, 3) the presently available data pertaining to metals impairments in the watershed, 4) the various contributing sources of metals based on recent data and studies, and 5) the metals TMDLs and allocations.

7.1 Mechanism of Effects of Excess Metals to Beneficial Uses

Water bodies with metals concentrations exceeding the aquatic life and/or human health standards can impair support of numerous beneficial uses including aquatic life, cold water fisheries, drinking water, and agriculture. Within aquatic ecosystems, elevated concentrations of heavy metals can have a toxic, carcinogenic, or bioconcentrating effect on biota. Humans and wildlife can suffer acute and chronic effects from consuming drinking water or fish with elevated metals concentrations. Because elevated metals concentrations can be toxic to plants and animals, high metals concentrations in irrigation or stock water may affect agricultural uses.

7.2 Stream Segments of Concern

As mentioned in **Section 1.1**, metals 303(d) listings for Silver Bow Creek (MT76G003_020) are not within the scope of this document and will be addressed in the future during Phase II TMDL development for the [mainstem] Clark Fork River TPA. Excluding Silver Bow Creek, a total of 14 water body segments in the Upper Clark Fork TPA were listed as impaired due to metals-related causes on the 2008 Montana 303(d) List (**Table 7-1**). All 2008 303(d) listings are included in **Table 1-1** and the beneficial use support status of listed segments is presented in **Table 3-1**. Metals-related listings include aluminum, arsenic, cadmium, chromium, copper, cyanide, iron, lead, manganese, selenium, sulfates, and zinc. Cyanide and sulfates are not metals but 303(d) listings are addressed within this document because they are frequently associated with metals and mining sources.

Table 7-1. Water body segments in the Upper Clark Fork TPA with metals listings on the 2008 303(d) List

Water Body ID	Stream Segment	Probable Causes of Impairment
MT76G003_031	**BEEFSTRAIGHT CREEK**, Minnesota Gulch to mouth (German Gulch)	Cyanide
MT76G005_071	**DUNKLEBERG CREEK**, headwaters SW corner Sec 2, T9N, R12W	Cadmium, Lead, Zinc
MT76G005_072	**DUNKLEBERG CREEK**, SW corner Sec 2, T9N, R12W to mouth (Clark Fork River)	Lead
MT76G003_030	**GERMAN GULCH**, headwaters to mouth (Silver Bow Creek)	Selenium

Table 7-1. Water body segments in the Upper Clark Fork TPA with metals listings on the 2008 303(d) List

Water Body ID	Stream Segment	Probable Causes of Impairment
MT76G005_091	**GOLD CREEK**, headwaters to the Natl. Forest boundary	Lead
MT76G002_072	**LOST CREEK**, the south State Park boundary to the mouth (Clark Fork River)	Arsenic, Iron, Manganese, Sulfates
MT76G002_051	**MILL CREEK**, headwaters to the section line between Sec 27 & 28, T4N, R11W	Arsenic, Cadmium, Chromium, Copper, Lead, Zinc
MT76G002_052	**MILL CREEK**, section line between Sec 27 & 28, T4N, R11W to the mouth (Silver Bow Creek)	Aluminum, Arsenic, Cadmium, Copper, Iron, Lead, Zinc
MT76G002_120	**MILL-WILLOW BYPASS** from confluence of Mill and Willow Creeks to Warm Springs Creek/Clark Fork River	Arsenic, Copper, Lead
MT76G002_080	**MODESTY CREEK**, headwaters to the mouth (Clark Fork River)	Arsenic
MT76G002_131	**PETERSON CREEK**, headwaters to Jack Creek	Copper
MT76G002_012	**WARM SPRINGS CREEK** (near Warm Springs), Meyers Dam (T5N, R12W, SEC 25) to mouth (Clark Fork)	Arsenic, Copper, Lead
MT76G002_061	**WILLOW CREEK**, headwaters to T4N, R10W, Sec30 (DABC)	Arsenic, Cadmium, Copper, Lead
MT76G002_062	**WILLOW CREEK**, T4N, R10W, Sec30 (DABC) to mouth (Silver Bow Creek)	Arsenic, Cadmium, Copper, Lead

7.3 Information Sources and Assessment Methods

The total metals load entering a water body is equal to the sum of all contributing source areas. In general, this means that headwater areas will have fewer potential source areas (although they frequently have a high concentration of abandoned mines), whereas locations lower in the watershed will have numerous potential source areas. To determine the location and magnitude of general sources, GIS layers, historical water quality data, and aerial photos were used.

GIS data included the DEQ High Priority Abandoned Hardrock Mine sites, the DEQ Abandoned Hardrock Mines database, the DEQ Active Hardrock Mine sites, the Montana Bureau of Mines and Geology (MBMG) Abandoned and Inactive Mines database, and permitted point sources (i.e. Montana Pollutant Discharge Elimination System permits) (**Appendix A, Figure A-19**). A query of active hardrock mine sites indicated no active hardrock mines in any of the drainages for the stream segments of concern in the Upper Clark Fork TPA (listed in **Table 7-1**). DEQ abandoned mine asssessment files were also reviewed for notes about potential sources including discharging adits, unstable tailings, and mining wastes in the floodplain. Additionally, the potential for mines in the MBMG database to affect surface water quality in metals-listed streams within the Upper Clark Fork TPA was assessed by reviewing the MBMG assessment of abandoned mines in the Deerlodge National Forest (Madison et al., 1998). Because geology and soil can influence water quality, geologic data from the USGS General Surficial Geology of Montana 1:500,000 scale map and soils data from the State Soil Geographic (STATSGO) database was also examined.

Many of the 303(d) listings are based on water column and sediment metals data from the 1970s and 1980s. Data collected earlier than 15 years ago (i.e. 1994) were used to aid in the initial coarse level source assessment, to help determine sampling locations for additional data collection, and to provide background concentrations, but are not used within this document in the existing data review due to potential data quality and reliability issues (e.g. reporting limits higher than water quality standards and uncertainty regarding collection, analysis and recording methods) and because conditions may have changed substantially since data collection. Particularly because of Superfund-related reclamation/restoration activities, data considered to represent the existing condition (i.e. existing concentrations and sources) is more recent in some watersheds (**Table 7-2**).

Information used for the data review and TMDL development includes DEQ's assessment data collected since 1994, DEQ abandoned mine data, samples collected at USGS gaging stations on Mill, Willow, Lost, and Warm Spring creeks (**Figures A-2b and A-8**), German Gulch and Beefstraight Creek samples collected by the USFS related to closure of the Beal Mountain Mine, and data collected to assist with reclamation and restoration activities at the Silver Bow Creek/Butte Area Superfund site and Anaconda Smelter Superfund Site. Water bodies addressed within this document that flow through Superfund sites are Mill Creek, Willow Creek, Lost Creek, Warm Springs Creek, German Gulch (at the mouth), and the Mill Willow Bypass. Numerous sampling events were conducted in 1993 to aid in Superfund Remedial Investigations (RI); those findings will be discussed during the review of existing conditions for water bodies that have had minimal restoration/reclamation activities (i.e. 1994 indicated as the existing condition within **Table 7-2**).

Table 7-2. Timescale of restoration/reclamation activities used to determine data representing the existing condition

Water Body ID	**Stream Segment**	**Timeline of Restoration/Reclamation Activities**	**Year [to present] Representing the Existing Condition**
MT76G003_031	Beefstraight Creek	<u>1997</u>: Beal Mtn Mine ceased operation <u>2000-current</u>: Beal Mtn Mine reclamation and treatment ongoing since 2000 <u>2003</u>: Biological treatment and land application of leach pad waste commenced <u>2010</u>: Completion of site reclamation (pending funding)	2003
MT76G005_071/_072	Dunkleburg Creek	None	1994

Table 7-2. Timescale of restoration/reclamation activities used to determine data representing the existing condition

Water Body ID	**Stream Segment**	**Timeline of Restoration/Reclamation Activities**	**Year [to present] Representing the Existing Condition**
MT76G003_030	German Gulch	1997: Beal Mtn Mine ceased operation 2000-current: Beal Mtn Mine reclamation and treatment ongoing since 2000 2003: Biological treatment and land application of leach pad waste commenced 2010: Anticipated completion of Beal Mtn Mine reclamation and removal of tailings near the mouth (Butte/Silver Bow Superfund site)	2003
MT76G005_091	Gold Creek	None	1994
MT76G002_072	Lost Creek	2003/2004: Storm water BMPs Slope reclamation planned within the next 3-5 years	1994
MT76G002_051/ _052	Mill Creek	1998: Storm water improvements to route water from Smelter Hill away from Mill Creek (Aspen Hill ditch) 2008: Reclamation project south of Hwy 1 2009/2010: Reclamation project north of Hwy 1 near gun club Slope reclamation and storm water basins on several tributaries planned within the next 3-5 years	1999
MT76G002_120	Mill Willow Bypass	1991: Tailings removed and dike built between bypass and Silver Bow Creek 1992: Channel reconstruction	1994
MT76G002_080	Modesty Creek	None	1994
MT76G002_131	Peterson Creek	None	1994
MT76G002_012	Warm Springs Creek (near Warm Springs)	West of Galen Hwy Bridge 1992: Stabilize Red Sands and repair levees 1994: 275,000 cubic yards waste material removed from vicinity of Arbiter Plant 04/1999: Remedial action completed for soil removal and/or stabilization, including floodplain wastes, heap roast slag, and miscellaneous wastes 09/2001: Red Sands remedial action completed 1999-2002: Remediation of Anaconda Ponds East of Galen Hwy Bridge Streamside tailings removal and stream restoration within next 3-5 years	2002
MT76G002_061/ _062	Willow Creek	Streamside tailings removal and stream restoration from Hwy 1 north to Stewart St within the next 3-5 years	1994

To add to the historical dataset and document seasonal variability, DEQ conducted metals water quality and sediment monitoring in 2007 and 2008 in the listed watersheds during spring runoff and base flow conditions (**Figure A-2b**). Sediment metals data was collected during base flow to aid in the source assessment. Metals-rich sediment can be a source of metals at mine sites as it is carried downstream and deposited in the stream channel or floodplain. Field and analytical protocols for the samples collected in 2007/2008 are described in the Upper Clark Fork TPA Metals Monitoring Sampling and Analysis Plan (DEQ, 2006), and raw data is contained in **Appendix D**. For all data reviewed, samples collected between April 15th and June 30th are assumed to represent high flow and all other samples are low flow (unless otherwise specified in a sampling report or collected during targeted storm-event sampling).

The effect of runoff on metals concentrations can vary, as spring runoff may dilute metals sources that enter the stream through ground water or may increase erosion and erode soils/tailings containing metals. Mining areas may contribute metals through ground water discharge, which occurs year-round, but tend to be more apparent during low flow when surface water inputs are minimal. Examining water quality data under various hydrologic conditions is necessary to characterize water chemistry metal conditions.

Based on the review of GIS and water quality data, potential sources of metals loading in the Upper Clark Fork TPA include:

- Natural background loading from mineralized geology
- Atmospheric deposition from Anaconda Smelter and other historical smelters
- Abandoned mines, including adit discharge/drainage from abandoned mines and runoff/drainage from abandoned mine tailings
- Upland, in-stream, and floodplain metals deposits from historical mining operations
- Inter-basin transfers (i.e. irrigation)
- Permitted point sources

7.3.1 Natural Background Loading

Natural background loading of metals occurs as a result of geologic conditions. Therefore, the degree of loading can vary considerably among sub-watersheds in the planning area, as geologic conditions vary throughout (**Figure A-5**). For instance, geothermal springs and volcanic geology can both result in an elevated background concentration of arsenic. Geothermal sources near Warm Springs, Fairmont, and Smelter Hill have been sampled and contained arsenic concentrations up to 30µg/L; based on the low flow rate of those sources, the potential load contribution is very small and several orders of magnitude smaller than that associated with ground water affected by atmospheric deposition from the Anaconda Smelter (study; personal comm. C. Coover, 2009). A study of ground water arsenic concentrations near Anaconda found a background concentration in areas of volcanic geology that ranged from 5 to 12µg/L (QST Environmental, 1999). Near both geothermal sources and areas with volcanic geology there was a clear gradient of greater arsenic concentrations in ground water near areas with high arsenic soil concentrations from anthropogenic sources. Overall, arsenic background sampling associated with the Anaconda Superfund Site RI found ground water concentrations in the bedrock aquifer decreased with depth near Anaconda and with distance from Anaconda with a background concentration generally less than 3µg/L (personal comm. C. Coover, 2009). Based on the sampling that has been conducted and because geologic influences can be very localized and the influence of ground water and degree of dilution in surface water is variable among streams, it is assumed that natural background sources alone would not result in the exceedance of arsenic (or other metals) target concentrations. In areas that have been historically mined or have received atmospheric deposition from historic smelters throughout the extent of the watershed, it is difficult to tease apart the background or natural level of a metal from that associated with anthropogenic sources. When possible, background loading will be accounted for separately from anthropogenic sources. However, because mining and/or smelting has affected all of the streams that are listed for metals impairment to some extent, the natural background loading may not be expressed separately from other loading, and even if it is expressed separately, a small component of the anthropogenic loading is assumed to be natural. The underlying assumption is that natural background sources alone would not result in the exceedance of TMDL target concentrations of metals in the water column, or in sediments. If future monitoring proves this to be incorrect, then these TMDLs may need to be revised in accordance with the Adaptive Management strategy provided in **Section 7.8**.

7.3.2 Atmospheric Deposition

Mining started in the Upper Clark Fork TPA in the 1860s with the discovery of gold, and by the 1880s, the focus shifted to copper and silver and smelting needs increased. By 1884, at least eight open air smelters were in operation (EPA, 2000). In 1884, the Old Works copper smelter was built along Warm Springs Creek. It was the largest smelter in operation until 1902, when it was replaced by the most prominent smelter in the watershed, the Anaconda Smelter (a.k.a. Washoe Smelter). The Anaconda Smelter operated until 1980. Arsenic is a major component of smelter stack particulates, but emissions from the Anaconda Smelter also contained cadmium, copper, lead, and zinc (EPA and DEQ, 1998). The areas in the watershed with greatest amount of atmospheric deposition fall within the Anaconda Smelter National Priority List (a.k.a. Superfund) Site. The Anaconda Smelter Site does not have rigid boundaries; monitoring efforts associated with the RI continue to document areas of smelter-associated contamination that were not previously identified (personal comm. C. Coover, 2009). However, elevated metals concentrations within several water bodies in the Upper Clark Fork TPA have been attributed to atmospheric deposition from the Anaconda Smelter. They include Modesty, Mill, Willow, Lost, and Warm Springs creeks. The Mill Willow Bypass is within both the Anaconda Smelter and Butte-Silver Bow site and has likely been affected by atmospheric deposition from the Anaconda Smelter and smelters along Silver Bow Creek. German Gulch is a tributary to Silver Bow Creek and near its mouth is part of the Butte-Silver Bow Superfund Site (**Figure A-19**); this portion of German Gulch, along with other areas within the Butte-Silver Bow Site, may be affected by historical atmospheric deposition from smelters along Silver Bow Creek, which ceased operating around 1910 (EPA, 2005) The Silver Bow Creek floodplain (which also contains mine tailings and other wastes) is being reclaimed as part of the Streamside Tailings Operable Unit within the Superfund cleanup. Atmospheric deposition resulted in increased metals concentrations and lower pH values (associated with sulfur dioxide) in soils that caused varying degrees of damage to vegetation and vegetative community composition (EPA and DEQ, 1998). In some areas, metals concentrations and/or acidic soil conditions were toxic to plants and reestablishment of vegetation has been limited, resulting in an increased risk of erosion and mobility of metals to surface water via runoff.

7.3.3 Abandoned Mines and Associated Wastes

As a result of the intensive historic mining, there are almost 400 abandoned mines within the Upper Clark Fork TPA (according to the DEQ and MBMG databases) (**Figure A-19**). Of the abandoned mines within watersheds with metals-related 303(d) listings, two have been ranked by DEQ as high priority abandoned mines, and both are in the Dunkleberg Creek watershed (**Figure A-19**). Abandoned mine types included in the databases are placer, hard rock/lode, mineral deposits, and quarries. Because of the different mine types in the databases, abandoned mine sites may range from small ground disturbances to areas with adits (which can be dry or discharging) and/or tailings and waste rock piles of different sizes. Waste rock dumps and tailings may be in upland areas, in the floodplain or streamside, or in the stream channel. Depending on the parent geology, stability and level of re-vegetation, and capacity to leach metals and/or generate acid mine drainage, the effects of mining wastes on stream water quality can vary greatly.

There is typically not enough data near individual mining sources to allocate a specific percentage of the TMDL to an individual site relative to other abandoned mine sources. In instances where there is adequate data, loading from abandoned mines, adits, and tailings will be evaluated as separate unpermitted point sources and provided distinct waste load allocations (WLA). Otherwise, the contribution from all abandoned mine sources (e.g. adits, waste rock, tailings) in a contributing area or entire watershed is grouped into a composite WLA from abandoned mines. This approach is premised on the assumption that reductions in metals loading can be achieved through the remediation of these abandoned mines and associated waste rock/tailings.

7.3.4 Storm Water

Typically, an increased metals load during storm events is associated with suspension of tailings or wastes in or adjacent to the stream channel or floodplain, and loading from other upland sources is minimal. However, because of the aerial extent of abandoned mine tailings and wastes in the Upper Clark Fork TPA, and the associated loss of upland and riparian vegetation (EPA and DEQ, 1998), storm water has the potential to be a major mechanism of metals loading from upland abandoned mine sources (as well as those in the floodplain and channel). This aspect of loading has been incorporated into the Anaconda Smelter Superfund Site reclamation; storm event loading studies have been completed for the water bodies within the site boundary to guide reclamation efforts and Storm Water Management Plans (SWMPs) are being developed to address Warm Springs Creek, Willow Creek, Lost Creek, Mill Creek, and the Mill-Willow Bypass. The SWMPs set a framework to govern storm water BMPs, assess storm event metals loading after the completion of Superfund reclamation/restoration projects, and provide an adaptive feedback loop to adjust BMPs if they are inadequate at decreasing storm event related metals loading.

The potential for upland storm event driven loading is recognized to help guide follow-up monitoring and TMDL implementation but is incorporated within the allocations to mining sources and will not be given a separate load allocation.

7.3.5 Inter-basin Transfers

The Upper Clark Fork is extensively irrigated, and many of the irrigation ditches cross through numerous listed water bodies (**Figure A-8**). Some of the ditches, such as Yellow Ditch, which historically withdrew water from Silver Bow Creek, inherently also transferred mining wastes across multiple watersheds, and may still contain remnants of these mining wastes today. Additionally, the diffuse nature of historic atmospheric deposition of metals resulting from smelter fallout and the widespread occurrence of it in the Upper Clark Fork TPA may also contribute to the transfer of metals via irrigation networks. Addressing metals sources within each listed watershed, including historic wastes along ditches and upland areas affected by atmospheric deposition, should generally address metals loading via inter-basin transfers. Because of this and also because of the complex nature of the irrigation network in the Upper Clark Fork TPA (**Figure A-8, and Appendix H**), ditches that are identified as significant sources may be treated as unpermitted point sources and given distinct waste load allocations, but most ditches, particularly if they are transferring metals associated with smelter fallout to other watersheds affected by the same source, will be incorporated into load allocations to historic mining wastes.

7.3.6 Point Sources

There are two permitted point sources in the Upper Clark Fork TPA that are within watersheds with metals listings on the 2008 303(d) List, and both permittees discharge to Warm Springs Creek. They are shown on **Figure A-19** and include:

- A General Industrial Storm Water MPDES permit (MTR000068) for Anaconda Foundry and Fabrication Company (AFFCO)
- An Individual MPDES permit (MTG130013) for Washoe Park Trout Hatchery

<u>AFFCO (MTR000068)</u>
The storm water permit for AFFCO allows for discharge of storm water into five storm sewers that discharge to Warm Springs Creek. The permit includes a Storm Water Pollution Prevention Plan and requires biannual reporting of discharge monitoring data. As a Primary Metal Industry Facility, metals-related monitoring required by the general permit includes flow, total suspended solids, arsenic, copper, lead, and zinc.

<u>Washoe Park Trout Hatchery (MTG130013)</u>
The Washoe Park Trout Hatchery has a flow through system that uses well water and discharges untreated effluent to Warm Springs Creek. Effluent monitoring includes fish food, total suspended solids, PCBs, biological oxygen demand, and nutrients but no metals-related monitoring is required.

7.4 Water Quality Targets

7.4.1 Targets

For pollutants with numeric standards, such as metals, the established state numeric water quality standards, as defined in Circular DEQ-7 (DEQ, 2008), is typically adopted as the water quality target. The acute and chronic numeric water quality standards, as defined in Circular DEQ-7, are adopted as water quality targets for the metals of concern in the Upper Clark Fork TPA. The metals of concern include aluminum, arsenic, cadmium, chromium, copper, cyanide, iron, lead, manganese, selenium, and zinc. Narrative standards found in Montana's general water quality prohibitions (ARM 17.30.637) apply to metals concentrations that are found associated with stream bottom sediments. **Section 3.0** contains additional details on applicable numeric and narrative standards for metals.

7.4.1.1 Water Column Metals Concentrations

DEQ Circular DEQ-7 (DEQ, 2008) contains numeric water quality standards for Montana's surface and ground waters that are set at concentrations necessary to protect the beneficial uses of the waters. Acute and chronic toxicity aquatic life standards are designed to protect aquatic life uses, while the human health standard is designed to protect drinking water uses. As defined in DEQ-7, compliance with chronic water quality standards is based on an average water quality metals concentration over a 96 hour period and acute water quality standards are applied as a 'not-to-exceed' value.

Water quality standards (acute and chronic aquatic life, human health) for each parameter of concern in the Upper Clark Fork TPA at a water hardness of 25 mg/L are shown in **Table 3-4**. The numeric aquatic life standards for most metals are dependent upon water hardness values, and as the hardness increases, the water quality standards for a specific metal also increases (i.e. becomes less stringent). Consequently, where the aquatic life numeric standards are used as the target, the water quality target values for specific metals will vary with water hardness. The acute and chronic aquatic life standards for cadmium, copper, lead, and zinc are hardness-dependent.

Water quality targets for metals are the State of Montana human health and acute and chronic aquatic life standards as defined in Circular DEQ-7. A TMDL will be written when either the aquatic life or human health standard is exceeded. As discussed in **Section 3.0**, the aquatic life numeric standards will be used as a target for iron, because the human health standards is a secondary maximum contaminant level based on aesthetic properties and would likely be removed via conventional treatment. Additionally, the human health standard for manganese is a secondary maximum contaminant level which is based on aesthetic water properties and would likely be removed via conventional treatment. If the data indicate that the human health guidance values for iron and manganese would be consistently exceeded after conventional treatment, use of the water body for drinking water is considered impaired for these constituents.

Montana does not have numeric water quality standards for sulfate. In a review of DEQ data from 71 reference sites in B-1 streams in Montana, sulfate concentrations ranged from 1.2 to 158mg/L. Toxicity tests (i.e. Whole Effluent Toxicology) by both the University of Michigan and British Columbia concluded that the lowest observed effects to most aquatic life, including salmonids, occurs at sulfate concentrations between 200 and 250mg/L (Boge et al., 1982a; Boge et al., 1982b; Denisger, 1998). Given that reference values are less than the lowest observed effects concentration, 200mg/L is an appropriate value to evaluate effects to aquatic life and will be used as a target for sulfate.

7.4.1.2 Technical Impracticability Waivers

Under CERCLA and RCRA, a technical impractability (TI) waiver may be established based on site-specific conditions to waive water quality standards for certain pollutants if the EPA determines that meeting specific water quality standards is not technically feasible. Based on extensive ground water contamination within the fractured bedrock aquifer and the alluvial aquifer (see **Figure A-22**, which indicates proposed ground water TI zones), TI waivers will be pursued for the arsenic human health standard for main stems and tributaries of Antelope and Dutchman creeks (tributaries in the Lost Creek watershed), Lost Creek, Mill Creek, Modesty Creek, and Willow Creek (personal comm. J. Griffin, 2009; personal comm. C. Coover, 2009). In the future, this may result in site-specific water quality standards for arsenic, and potentially other metals, which would result in a different water quality target and TMDL. However, at this time, there are no site-specific water quality standards and all water quality targets within the Upper Clark Fork TPA are the water quality standards as defined within DEQ-7.

7.4.2 Supplemental Indicators

7.4.2.1 Sediment Metals Concentrations

As discussed in **Section 3.0**, narrative standards found in Montana's general water quality prohibitions apply to metals concentrations that are found in stream bottom sediments. Stream sediment data may also be indicative of beneficial use impairment caused by elevated metals and are used as supplementary indicators of impairment. In addition to directly impairing aquatic life that interacts with the elevated metals in the sediment, the elevated sediment values can also be an indicator of elevated concentrations of metals during runoff conditions. This can be a particularly important supplemental indicator when high flow data is lacking or limited.

The National Oceanic and Atmospheric Administration (NOAA) has developed Screening Quick Reference Tables that contain metals concentration guidelines for freshwater sediments (NOAA, 2008). Screening criteria concentrations come from a variety of toxicity studies and are expressed in Probable Effects Levels (PELs) (**Table 7-3**). PELs represent the sediment concentration above which toxic effects frequently occur, and are calculated as the geometric mean of the 50th percentile concentration of the toxic effects data set and the 85th percentile of the no-effect data set. Although the State of Montana does not currently have criteria that define impairment condition based on sediment quality data, PELs provide a screening tool to evaluate the potential for impacts to aquatic life and will be used as a supplemental indicator to assist in impairment determinations where water chemistry data are limited (**Table 7-3**). Because numeric standards exist for metals in water and sediment standards are narrative, sediment metals information will be used as a supplemental indicator to water column data.

Table 7-3. Screening level criteria for sediment metals concentrations that will be used as supplemental indicators in the Upper Clark Fork TPA.

Metal of Concern	PEL (µg/g dry weight)
Arsenic	17
Cadmium	3.53
Chromium	90.0
Copper	197
Lead	91.3
Selenium[1]	2.0
Zinc	315

[1] The screening value for selenium is based on the BC Ministry of Environment sediment standard (2006)

7.4.2.2 Fish Tissue Concentrations and Body Structure

Fish tissue concentrations and/or organ deformation will be used, when available, as supplemental indicators for metals impairment for streams in which the sediment metals concentrations exceed guidance values and water samples meet the water quality targets. In general, biological data is limited for tributaries in the Upper Clark Fork TPA and water bodies with the most data also have large water quality datasets.

On a side note, macroinvertebrate indices were also considered as a supplemental indicator but samples were generally limited to the mouth of tributaries and/or limited to a single sampling event that precluded comparisons along the length of listed segment or over time.

7.4.2.3 Anthropogenic Metals Sources

The presence of anthropogenic metals sources does not always result in impairment of a beneficial use. When there are no significant identified anthropogenic sources of metals within the watershed of a 303(d) listed stream, no TMDL will be prepared since Montana’s narrative standards for metals relate to anthropogenic causes. Anthropogenic and natural sources will be evaluated using recently collected data, field observations and watershed scale source assessment information obtained using aerial imagery, GIS data layers, and other relevant information sources.

7.4.3 Summary of Targets and Supplemental Indicators for Metals

The metals targets and supplemental indicators are summarized in **Table 7-4**. TMDL determination is based on the following assumptions:

- Natural levels of metals are below the chronic water quality standards for aquatic life under all flow conditions.
- Single water quality samples represent a 96-hour average water quality condition.

Whether or not a TMDL is developed depends on several factors:

- If there are any recent exceedances of the water quality target and accompanying known anthropogenic sources, a TMDL will be developed.
- If the water body segment is currently listed for a particular metal. If all water quality targets and sediment supplemental indicator values are met but the water body segment is listed and the source assessment indicates anthropogenic sources, a TMDL will be developed. If all targets and supplemental indicator values are met but no anthropogenic sources are identified, follow-up monitoring will be recommended.
- If there are no recent representative water quality target exceedances, but there is insufficient data to fully evaluate all seasonal flow conditions, then additional monitoring may be recommended instead of TMDL development.
- If water column samples meet water quality targets, available sediment metals data and biological toxicity metrics will be reviewed and compared to supplemental indicator values. TMDL development determinations in situations without exceedances in water column data depend on the presence of anthropogenic sources and the number and magnitude of exceedances in sediment samples (typically >2x PEL is used as a magnitude threshold). If water column measurements meet the water quality targets, but both biological metrics (if available) and the sediment metals concentrations exceed the supplemental indicator criteria described within this document, a TMDL will be prepared or follow-up monitoring will be conducted.

Table 7-4. Targets and Supplemental Indicators for Metals in the Upper Clark Fork TPA.

Water Quality Targets	**Proposed Criterion**
Montana’s numeric water quality standards	As described in Circular DEQ-7
Supplemental Indicators	**Proposed Criterion**
Sediment metal concentrations (µg/g dry weight)	Not impeding aquatic life use support: Comparable to PEL guidance values (see **Section 7.4.2.1**)
Fish tissue concentrations and body structure	No elevated metals concentrations in fish tissue and no organ deformation
Anthropogenic metals sources	No significant anthropogenic sources

7.4.4 Existing Condition and Comparison to Water Quality Targets

For each water body segment listed on the 2008 303(d) List for metals, anthropogenic sources will be reviewed, and then recent water quality and sediment data will be evaluated relative to the water quality targets and supplemental indicators to make a TMDL development determination. Data for any metals listings will be evaluated first and will be followed by any other metals with target or supplemental indicator exceedances.

7.4.4.1 Beefstraight Creek (MT76G003_031)

Beefstraight Creek (**Figure A-23**) was listed for cyanide on the 2008 303(d) List. Beefstraight Creek extends 5.1 miles from its headwaters to its mouth at German Gulch.

Sources and Available Data
There are no high priority abandoned mines in the Beefstraight Creek watershed. Although there are two abandoned placer mines in the lower watershed downstream of the confluence with American Gulch and near the mouth of Beefstraight Creek (**Figure A-23**), the probable source of the cyanide listing is Beal Mountain Mine, a closed open-pit cyanide heap leach mine that the USFS is reclaiming under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The mine site is predominantly located along German Gulch upstream of its confluence with Beefstraight Creek, but a portion of the mine site near the heap leach pad and where leach pad wastes have been land applied is along Minnesota Gulch and American Gulch, both tributaries to Beefstraight Creek.

The mine closed in 1997 and gold recovery from the heap leach pad was completed in 1999. After mine closure, the responsible party filed for bankruptcy; the USFS has conducted some remediation work and is currently responsible for final mine closure. Biologically treated heap leach waste was land applied during mine operation and continued sporadically after mine closure until October 2005 (Tetra Tech, 2007). Because of the hydrologic connection between ground water in the land application areas and Beefstraight Creek and Minnesota Gulch, the land application was previously part of a Montana Pollutant Discharge Elimination System (MPDES) permit. Because the water level in the leach pond has increased to an unstable level since land application ceased in 2005, heap leach waste was treated in 2008 by reverse osmosis and then land applied. The Beaverhead Deerlodge National Forest is finalizing an engineering evaluation and cost analysis for the preferred reclamation alternative and anticipates beginning reclamation and completing treatment of heap leach water in 2010. One of the reclamation goals is to reduce or eliminate the influx of water into the leach pad and end the land application of wastes after the existing waste is treated to a safe volume (personal comm., M. Browne, 2009).

No known cyanide heap leach mining occurred in the watershed prior to the Beal Mountain Mine. Cyanide is produced by some plants and microbes but is generally a man-made substance. Twelve background samples were collected in 1987 in German Gulch and its tributaries prior to construction of the Beal Mountain Mine. Additionally, nine samples were collected by the USFS upstream of the mine between 2003 and 2008 (site STA-4). All total cyanide values were below the detection limit (i.e. 10µg/L for 1980s samples and 5µg/L for recent samples). The USFS has conducted extensive sampling in Beefstraight Creek related to the reclamation and closure of the Beal Mountain Mine. At a site downstream of Minnesota Gulch and American Gulch (BS-D) (**Figure A-23**), forty samples were collected and analyzed for cyanide (and numerous metals) monthly between 2003 and 2005 and also in 2006 and 2008 during high flow and base flow (**Table 7-5**). Samples have also been collected from five springs within the Beefstraight Creek watershed and a pond collecting drainage from under a leach pad that typically overflows and infiltrates into the ground in the Minnesota Gulch during runoff (**Figure A-23**). These extra samples will be used to help in the source assessment and loading analysis. Beefstraight Creek was initially listed for cyanide based on the USFS data collected in 2003. Because of the large amount of USFS data, DEQ analyzed no additional samples for cyanide during TMDL development.

Water samples were collected by DEQ from four sites during low flow in 2007 and high flow in 2008 (**Figure A-23**) and analyzed for metals commonly associated with abandoned mines (e.g. arsenic, copper, cadmium, lead, zinc, etc) and for selenium because of elevated selenium concentrations at Beal Mountain Mine and in German Gulch. Selenium and all other metals met all water quality targets.

Table 7-5. Summary of cyanide data relative to water quality standards for site BS-D on Beefstraight Creek.

Bold denotes water quality target exceedances.

Flow Conditions	**n**	**Chronic Exceedances**	**Acute Exceedances**	**Concentration Range (µg/L)**
All	40	29	7	<5 - 77
High flow	12	6	4	<5 - 37
Low flow	28	2	21	<5 - 77

Comparison to Water Quality Targets and TMDL Development Determination

Cyanide

Of the recent samples collected by the USFS, 73 percent of the samples exceeded the chronic aquatic life standard for cyanide and 18 percent exceeded the acute aquatic life standard for cyanide (**Table 7-5**). Because intensive post mine closure sampling was conducted in 2003, close to half of the samples were collected in 2003. Sample data with corresponding flow measurements were plotted to help assess if target exceedances exhibit a flow-related trend (**Figure 7-1**). Although more samples were collected at low flow compared to high flow (**Table 7-5**), there does not appear to be a flow-related trend to the target exceedances. Heap leach waste has been treated and land applied sporadically since 2001, and cyanide concentrations in the heap leach pad have declined during that time period (Maxim Technologies, Inc., 2005). This decline is mirrored in the sample data; all of the exceedances of the acute aquatic life standard occurred in 2003. Samples below the detection limit (i.e. 5µg/L) are plotted at half of the detection limit in **Figure 7-1**, and four of the seven non-detects occurred in 2006 and 2008. However, despite a decline in target exceedances and no recent exceedances of the acute standard, target exceedances continue to occur and a cyanide TMDL will be developed for Beefstraight Creek.

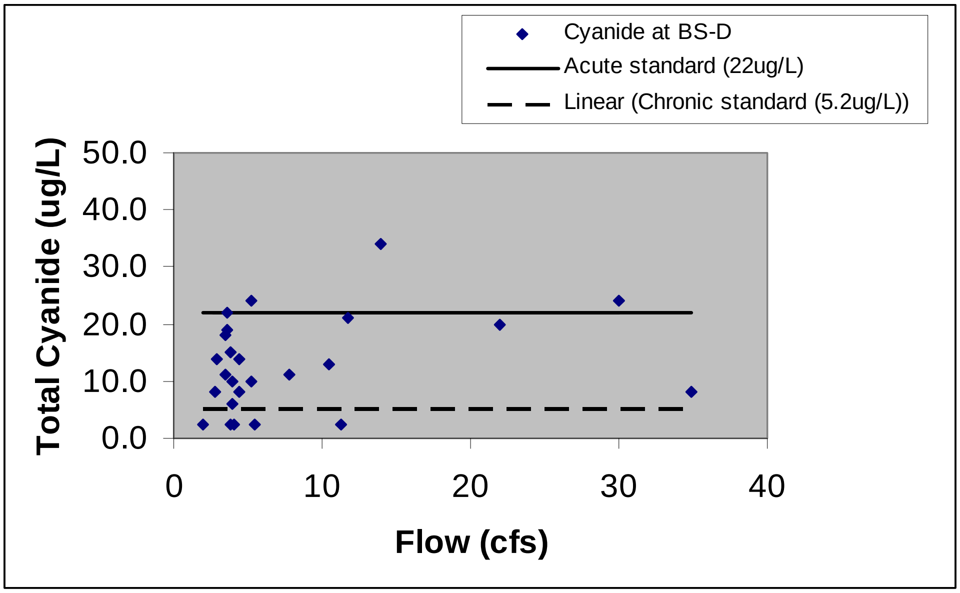


Figure 7-1. Cyanide data for Beefstraight Creek relative to the aquatic life standard.

Copper

Although none of the recent DEQ samples had target exceedances for other metals, a single USFS sample collected at BS-D in November 2003 had a copper concentration of 52µg/L, which exceeds both the chronic and acute aquatic life standard. Twenty five subsequent samples were equal to or less than 2µg/L, with 18 of the samples being less than the detection limit (1µg/L). Leachate that was biologically treated and then land applied had a concentration of 186µg/L in October 2003 (which was three times greater than the next highest measured concentration) and a sample from a ground water spring near the confluence of Minnesota Gulch and Beefstraight Creek (SPR-D8) had an elevated copper concentration of 16µg/L on the same day as the target exceedance in Beefstraight Creek, indicating the single target exceedance is likely a valid value related to the land applied wastes. All other treated leachate values during the period of biological treatment (i.e. 2001- 2005) were between 30 and 59µg/L.

There is no recent sediment metals data to assess as a supplemental indicator; no samples were collected during DEQ sampling in 2007/2008 because of a lack of depositional areas with fine-grained sediment at the sample sites. Future sediment sampling is recommended but the lack of fine-grained sediment limits the potential for metals accumulation within the bed sediment. FWP analyzed the whole-body copper content of westslope cutthroat trout and eastern brook trout collected at station BS-D between 2002 and 2007. The highest concentration occurred in 2004 but all values were less than literature toxicity values (Tetra Tech, 2009).

Copper concentrations in Beefstraight Creek, Minnesota Gulch, the leach pond, and springs around the mining site have generally declined since the mine closure and the current reverse osmosis leachate treatment has a much greater treatment capacity than the biological treatment formerly used at the mine (Tetra Tech, 2009). Because the copper concentrations in fish tissue samples are less than toxic levels, the water quality has improved since 2003, and there are numerous samples collected since November 2003 with no target exceedances, the elevated copper value from 2003 is not representative of current conditions and no copper TMDL will be developed for Beefstraight Creek. Note, despite a decrease in concentration, copper concentrations in the leachate are still well over target values and require treatment prior to land application or discharge (Tetra Tech, 2009).

7.4.4.2 Dunkleberg Creek, Upper Segment (MT76G005_071)

The upper segment of Dunkleberg Creek (**Figure A-24**) was listed for cadmium, lead, and zinc on the 2008 303(d) List and extends 3.6 miles from the headwaters to the southwest corner of Section 2, Township 9N, Range 12W.

Sources and Available Data
There are numerous abandoned mines in the upper part of the Dunkleberg Creek watershed, including two priority abandoned mines (**Figure A-24**). The priority abandoned mines are Forest Rose Mine and Jackson Park Mine. Forest Rose is located within the floodplain of upper Dunkleberg Creek and was a mining and milling site that produced lead, silver, copper, and zinc ore. The site contains a waste rock dump that forms a dam across the creek, multiple seeps, two discharging adits, and three tailings impoundments that span roughly 1200 feet of the channel (Madison et al., 1998; MCS Environmental, 2004). A USFS Site Investigation estimated 95,000 cubic yards of tailings and 21,000 cubic yards of waste rock are present at the site, and the tailings depth at the impoundments ranges from 35 to 68 feet thick (MCS Environmental, 2004). In 1992, the most downstream tailings impoundment was breached and released water and tailings downstream (MCS Environmental, 2004). Some seeps flow through the mine site and go subsurface, but other seeps near the impoundment breach area combine with piped impoundment water and flow into Dunkleberg Creek (MCS Environmental, 2004). Based on low metals concentrations in 2004, the site investigation concluded buffering reactions within the tailings and resulting metals precipitation is limiting the export of metals into Dunkleberg Creek, but the study also concluded tailings are likely transported downstream during runoff events (MCS Environmental, 2004).

Jackson Park, the other priority abandoned mine in the watershed, is located in the upper watershed on a tributary to Dunkleberg Creek (**Figure A-24**). During a 1993 DEQ priority mine assessment, 12 caved adits were noted at the Jackson Park site, but none were flowing and no seeps were observed. The site has approximately 6,345 cubic feet of waste rock and is in an area where several other abandoned mines are located. Of the non-priority abandoned mines in the DEQ and MBMG databases, tailings were noted for several mines but no discharging adits were noted in the assessment files.

Dunkleberg Creek was initially listed based on DEQ and USFS data from the 1970s and early 1990s. Samples collected by DEQ during an assessment of Forest Rose Mine in 1993 were elevated for copper, lead, iron, and zinc. Recent data includes four sites where sediment samples and high and low flow water samples were collected by DEQ in 2007 and 2008 near the priority mines and water and sediment samples collected by the USFS in 2003 as part of a site investigation for Forest Rose Mine (**Figure A-24**; **Tables 7-6** and **7-7**). The sampling in 2003 also included a tailings seep that flows within and next to the most downstream impoundment (TS-07-0-SW). Note, although an entire suite of metals was sampled, only listed metals or those with target exceedances are presented in **Tables 7-6** and **7-7**.

Table 7-6. Metals concentrations in the upper segment of Dunkleberg Creek.
Bold denotes a target exceedance.

Sample Site	Location	Sample Date	Flow (cfs)	Hardness (mg/L as $CaCO_3$)	Total Recoverable Metal in Water Column (µg/L)[1]					
					As	Cd	Cu	Fe	Pb	Zn
STR-13-0-SW	Upstream of waste rock dump	8/8/2003	---	167	<10	<2	<3	---	<5	108
STR-01-0-SW	25ft d/s of lowest impoundment	8/8/2003	---	297	<10	<2	<3	---	<5	64.1
DNK-01	Downstream of Forest Rose Mine	9/7/2007	0.9	295	<3	**1.09**	5	790	**48**	130
DNK-02	Tributary d/s of Forest Rose Mine	9/7/2007	0.33	117	<3	0.15	<1	<50	<0.5	20
DNK-03	Tributary near USFS Rd. 5160 & Jackson Park Mine	9/11/2007	1.5	203	<3	**0.53**	2	770	**19.6**	100
DNK-05	Dunkleberg Creek at crossing downstream of FS land	9/11/2007	1.36	173	<3	0.23	2	470	**11.2**	30
DNK-01	Downstream of Forest Rose Mine	5/20/2008	0.8	298	5	**2.1**	9	**1580**	**112**	240
DNK-02	Tributary d/s of Forest Rose Mine	5/20/2008	2.66	91	<3	<0.08	1	290	0.6	<10
DNK-03	Tributary near USFS Rd. 5160 & Jackson Park Mine	5/20/2008	1	188	<3	**1.91**	2	480	**12.8**	140
DNK-05	Dunkleberg Creek at crossing downstream of FS land	5/20/2008	3.61	131	7	**1.81**	**14**	**3520**	**105**	220
TS-07-0-SW	Tailings seep that flows within and next to impoundment failure	8/8/2003	---	1170	**33**	**42**	**217**	---	**85.9**	**6130**

[1] Samples collected in 2003 are total metals values, which may result in higher concentrations than total recoverables analysis

Table 7-7. Sediment metals concentrations in upper Dunkleberg Creek (ug/g dry weight).
Bold denotes a supplemental indicator value exceedance.

Sample Site	Sample Date	As	Cd	Cu	Pb	Zn
STR-15-0.1-S (near STR-13)	9/3/2003	**33.0**	**38.8**	11.2	**201**	**2170**
STR-02-0.1-S (near STR-01)	9/3/2003	13.8	**5.73**	63.9	**299**	**563**
DNK-01	9/7/2007	**240**	**34**	**276**	**3160**	**3980**
DNK-02	9/7/2007	**23.7**	**5.4**	**222**	**187**	**849**
DNK-03	9/11/2007	**18.7**	**6.65**	116	**481**	**1240**
DNK-05	9/11/2007	**30.6**	**7.64**	148	**445**	**1270**

Comparison to Water Quality Targets and TMDL Development Determination

Cadmium

Out of ten samples, five samples exceeded the cadmium water quality target. Water quality target exceedances occurred during high and low flow, but concentrations were greater during high flow. Additionally, the tailings seep had an elevated cadmium concentration and all of the sediment samples exceeded the supplemental indicator value for cadmium. Although sediment sample STR-15-0.1-S was collected upstream of the waste rock dump, the Forest Rose Site Investigation (MCS Environmental, 2004) attributed the elevated sediment concentrations to historical mining activities. The abandoned mine databases do not indicate any mining sources along the tributary with site DNK-02 (**Figure A-24**). Although the sediment concentration at site DNK-02 may be elevated because of an unknown mining source, it could also be related to local geology. However, sediment concentrations are greater near Forest Rose mine, indicating anthropogenic sources are definitely contributing to elevated sediment concentrations. Based on the target and supplemental indicator value exceedances, a cadmium TMDL will be developed for the upper segment of Dunkleberg Creek.

Sediment metals concentrations at DNK-02 are generally the same for other metals of concern: they are slightly elevated but much greater at DNK-01 near the Forest Rose mine and attributable to anthropogenic sources.

Lead

Six of the samples exceeded the lead water quality target; although concentrations were greater during the high flow sampling event, exceedances also occurred during low flow. Additionally, the tailings seep had an elevated lead concentration and all of the sediment samples exceeded the supplemental indicator value for lead. The sediment concentration immediately downstream of Forest Rose mine was the greatest and almost 35 times the PEL. Based on the target and supplemental indicator value exceedances, a lead TMDL will be developed for the upper segment of Dunkleberg Creek.

Zinc

One sample collected at the downstream end of the segment (DNK-05) during high flow exceeded the zinc water quality target. Additionally, the tailings seep had an elevated zinc concentration and all of the sediment samples exceeded the supplemental indicator value for zinc. The sediment concentration immediately downstream of Forest Rose mine was the greatest and almost 13 times the PEL. Based on the target and supplemental indicator value exceedances, a zinc TMDL will be developed for the upper segment of Dunkleberg Creek.

Copper and Iron

Although Dunkleberg Creek is not listed for copper or iron, one high flow sample exceeded the copper water quality target for copper and two high flow samples exceeded the iron water quality target. Additionally, the tailings seep had an elevated copper concentration and although the sample was not analyzed for iron, the Forest Rose Site Investigation (MCS Environmental, 2004) noted orange staining near a seep and orange-stained tailings and waste rock because of oxidation of pyrite (which contains iron). Two of the sediment samples exceeded the supplemental indicator value for copper. Based on the target and supplemental indicator value exceedances, copper and iron TMDLs will be developed for the upper segment of Dunkleberg Creek.

Arsenic
Dunkleberg Creek is not listed for arsenic, and although none of the samples exceeded the arsenic targets, five sediment samples exceeded the supplemental indicator value for arsenic. Concentrations at most sites were less than twice the PEL for arsenic, but the concentration at DNK-01, near Forest Rose mine, was 14 times the PEL. Additionally, the Forest Rose Site Investigation (MCS Environmental, 2004) noted elevated arsenic concentrations in surface and subsurface tailings samples and waste rock samples. Based on the known anthropogenic source and the magnitude of the supplemental indicator exceedance near the mine, an arsenic TMDL will be developed for the upper segment of Dunkleberg Creek.

pH
During the site investigation for Forest Rose Mine, evidence of acid generation and leaching of metals within the tailings was observed but high pH, calcium, and magnesium values indicated that buffering reactions within the tailings were limiting the precipitation of metals into Dunkleberg Creek and not affecting pH values within the creek. However, based on the acid generating capacity of the tailings, the investigation concluded the risk of acid mine drainage could increase in the future (MCS Environmental, 2004). During high flow sampling in 2008, pH values were 8.07 and 8.04 at the sites within Dunkleberg Creek (DNK-01 and -05), but during low flow sampling in 2007, the pH was 6.89 near the mine (DNK-01) and 5.59 at the bottom of the segment (DNK-05). Although additional monitoring is recommended, the pH change is likely related to acid mine drainage associated with Forest Rose Mine. Therefore, this pH change is greater than that allowed by Montana water quality standards (i.e. <0.5 pH unit; see **Section 3.0** for more details). No pH TMDL will be pursued because reclamation activities needed to meet the metals TMDLs in the upper segment of Dunkleberg Creek will also address sources of acid mine drainage.

7.4.4.3 Dunkleberg Creek, Lower Segment (MT76G005_072)

The lower segment of Dunkleberg Creek (**Figure A-24**) was listed for lead on the 2008 303(d) List and extends 4.7 miles from the bottom of the upper segment (southwest corner of Section 2, Township 9N, Range 12W) to the mouth at the Clark Fork River.

Sources and Available Data
The lower segment of Dunkleberg Creek may receive some metals loading from the Forest Rose and Jackson Park mines, priority mines in the upper watershed, but the abandoned mines databases do not indicate mining sources along the lower segment of Dunkleberg Creek. Dunkleberg Creek is a tributary to the Clark Fork River, which has been documented as having elevated metals in the floodplain as a result of historical mining sources upstream (Lipton, 1993). The highest floodplain tailings concentrations along the Clark Fork River occur upstream of Deer Lodge (which is upstream of Dunkleberg Creek). An additional potential source of metals to the lower segment of Dunkleberg Creek is an irrigation channel that withdraws from the Clark Fork River near Hoover Creek and mixes with Dunkleberg Creek near its mouth (**Figure 7-2** and

Figure A-24). The portion of the Clark Fork River where the irrigation withdrawal is located is on the 2008 303(d) List for arsenic, copper, lead, and zinc (MT76G001_010).

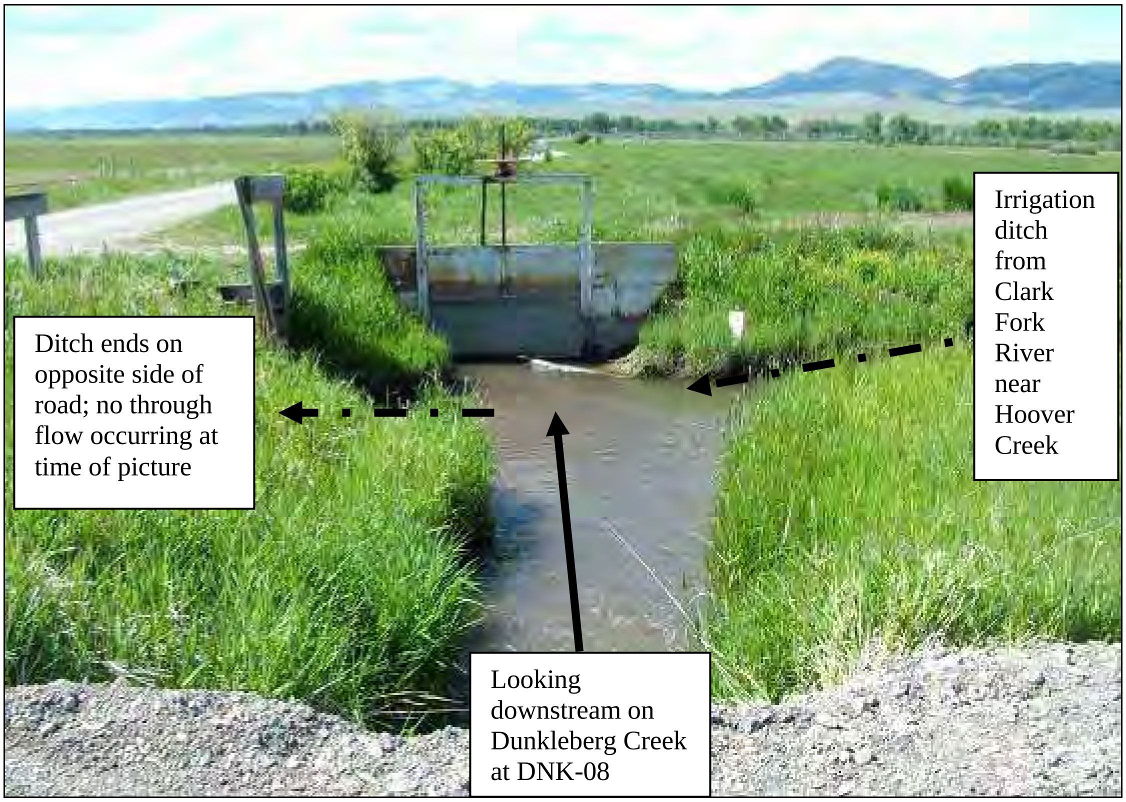


Figure 7-2. Looking downstream on Dunkleberg Creek at DNK-08 showing mixing with irrigation ditch from the Clark Fork River. Arrows indicate flow direction.

The lower segment of Dunkleberg Creek was originally listed for lead based on data collected near the mouth in the late 1970s. Recent data includes sediment samples and high and low flow water samples collected by DEQ in 2007 and 2008 at three sites (**Figure A-24**; **Tables 7-8** and **7-9**). Based on the site visit notes, the ditch from the Clark Fork River was flowing during high and low flow sampling. Data for site DNK-05 were discussed above relative to the upper segment of Dunkleberg Creek (**Section 7.4.4.2**) but are also included here because the site is close to the boundary of the upper and lower segment. Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented in **Tables 7-8** and **7-9**. **Table 7-8** also includes samples collected at the USGS gage on the Clark Fork River near Gold Creek (#12324680), which is the closest gage station to the irrigation withdrawal location (**Figures A-8** and **A-24**).

Table 7-8. Metals concentrations in the lower segment of Dunkleberg Creek and the Clark Fork River at Gold Creek.
Bold denotes a target exceedance. E = estimated flow value

Sample Site	**Location**	**Sample Date**	**Flow (cfs)**	**Hardness (mg/L as CaCO3)**	**Total Recoverable Metal in Water Column (µg/L)**					
					As	**Cd**	**Cu**	**Fe**	**Pb**	**Zn**
DNK-05	Dunkleberg Creek at crossing d/s of FS land	9/11/2007	1.36	173	< 3	0.23	2	470	**11.2**	30
DNK-06	Tributary at Powerline Access Rd	9/11/2007	0.022	196	< 3	<0.08	1	330	<0.5	<10
DNK-08	U/s of ditch from Clark Fork River	9/11/2007	2.5 E	205	3	<0.08	2	330	1.5	<10
DNK-05	Dunkleberg Creek at crossing d/s of FS land	5/20/2008	3.61	131	7	**1.81**	**14**	**3520**	**105**	**220**
DNK-06	Tributary at Powerline Access Rd	5/20/2008	0.1	158	< 3	<0.08	1	460	0.8	<10
DNK-08	U/s of ditch from Clark Fork River	5/20/2008	Ponded	187	4	0.11	2	550	4.4	10
DNK-09	At Jens Rd crossing	5/20/2008	8 E	119	**15**	0.17	**24**	**1390**	**5.8**	40
USGS-12324680	Clark Fork River near Gold Creek	8/28/2007	140	190	**10.9**	0.04	5.9	42	0.26	3.6
		5/08/2008	661	150	**14.3**	0.23	**42.9**	976	**6.13**	41.9
		6/04/2008	1,670	110	**20.3**	0.27	**59.9**	**1240**	**8.30**	53.5

Table 7-9. Sediment metals concentrations in lower Dunkleberg Creek (ug/g dry weight).
Bold denotes a supplemental indicator exceedance

Sample Site	**Sample Date**	**As**	**Cd**	**Cu**	**Pb**	**Zn**
DNK-05	9/11/2007	**30.6**	**7.64**	148	**445**	**1270**
DNK-06	9/11/2007	5.5	< 0.5	77	27.1	106
DNK-08	9/11/2007	9.1	1.75	131	90.9	303

Comparison to Water Quality Targets and TMDL Development Determination

Lead

Three of the seven samples exceeded the water quality target for lead. The exceedances occurred in the upper part of the segment (DNK-05) and near the mouth (DNK-09). The sediment sample at DNK-05 was the only sample that exceeded the supplemental indicator value for lead, however, there is no sediment chemistry data for DNK-09. Lead concentrations in the Clark Fork River that were collected close to the time of the target exceedance at DNK-09 also exceed water quality targets and are similar to the concentration at DNK-09. The similarities between lead concentrations at DNK-09 and in the Clark Fork River coupled with lower concentrations that attain water quality targets at DNK-08, which is immediately upstream of the ditch, indicate the irrigation ditch is an anthropogenic source of metals to Dunkleberg Creek. Based on the target and supplemental indicator value exceedances, a lead TMDL will be developed for the lower segment of Dunkleberg Creek.

Arsenic, Cadmium, Copper, Iron, and Zinc
Although the lower segment of Dunkleberg Creek is only listed for lead, several other metals exceeded water quality targets at DNK-05 and DNK-09. One high flow sample from DNK-05 exceeded water quality targets for cadmium, copper, iron, and zinc. Additionally, a sediment sample from DNK-05 exceeded the supplemental indicator values for arsenic, cadmium, and zinc. One high flow sample from DNK-09 exceeded water quality targets for arsenic, copper, and iron and was similar in concentration for those constituents to samples from the Clark Fork River during that time period. Based on the target and supplemental indicator value exceedances, arsenic, cadmium, copper, iron, and zinc TMDLs will be developed for the lower segment of Dunkleberg Creek.

There is no low flow data for DNK-09; although metals concentrations in the Clark Fork River during low flow in 2007 all met water quality targets with the exception of arsenic (**Table 7-8**), suggesting the ditch is predominantly contributing to target exceedances in lower Dunkleberg Creek during high flow, low flow monitoring and sediment chemistry data are recommended at DNK-09. Future sampling of the irrigation ditch during high and low flow is also recommended to better understand the effect of the ditch on water quality in lower Dunkleberg Creek.

7.4.4.4 German Gulch (MT76G003_030)

German Gulch (**Figure A-23**) was listed for selenium on the 2008 303(d) List. It extends 8.4 miles from its headwaters to the mouth at Silver Bow Creek.

Sources and Available Data
There are no priority abandoned mines within the watershed, but the abandoned mine databases identify several placer mines in the German Gulch watershed (**Figure A-23**), including those discussed for Beefstraight Creek (**Section 7.4.4.1**). The majority of placer mining (and also hydraulic mining) occurred upstream of Beefstraight Creek from the 1860s to early 1900s. Additionally, some limited lode mining occurred in the drainage. However, the most likely source of selenium is Beal Mountain Mine, a closed open-pit cyanide heap leach mine that the USFS has placed under CERCLA authority. German Gulch was initially listed for selenium based on data collected by the mine in the late 1990s. As discussed above in **Section 7.4.4.1**, the USFS has conducted some remediation work and is currently responsible for final mine closure. The Beaverhead Deerlodge National Forest plans to finalize an engineering evaluation and cost analysis for the preferred reclamation alternative in summer 2009 and will likely begin reclamation in 2010 (personal comm., M. Browne, 2009). An additional potential source of metals to lower German Gulch is historical mining wastes and atmospheric deposition that originated from sources along Silver Bow Creek, which is part of the Silver Bow-Butte Area Superfund Site (**Figure A-23**). The Streamside Tailings Operable Unit, which includes Silver Bow Creek and mining wastes within its floodplain, is the portion of the Superfund Site near the

mouth of German Gulch (**Figure A-19**). The tailings contain arsenic, lead, copper, cadmium, mercury, and zinc (EPA, 2000).

Beal Mountain Mine conducted background monitoring in 1987 at 5 sites in German Gulch prior to starting construction for the mine. However, as a result of historical mining in the upper watershed, there was a discharging adit just downstream of STA-4 (**Figure 7-3**) that resulted in elevated arsenic and sulfate concentrations at sites downstream of STA-4. The adit was later dismantled during Beal Mountain Mine construction. Because of the influence of the adit on water quality downstream of STA-4, only the four samples collected at STA-4 will be considered background. Nine additional samples were collected by the USFS at STA-4 between 2003 and 2008. All 1980s background selenium values were below the detection limit (5µg/L) and all recent background samples were equal to or less than 3µg/L.

The USFS has conducted extensive sampling in German Gulch related to the reclamation and closure of the Beal Mountain Mine. One hundred and thirty samples were collected at six sites from the headwaters to downstream of Beefstraight Creek monthly between 2003 and 2005 and also in 2006 and 2008 during high flow and base flow (**Table 7-10** and **Figure 7-3**). Other recent data includes sediment samples and high and low flow water samples collected by DEQ in 2007/2008 at five sites from downstream of Beal Mountain Mine to the mouth (**Tables 7-10** and **7-11**; **Figure 7-3**). Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented in **Tables 7-10** and **7-11**.

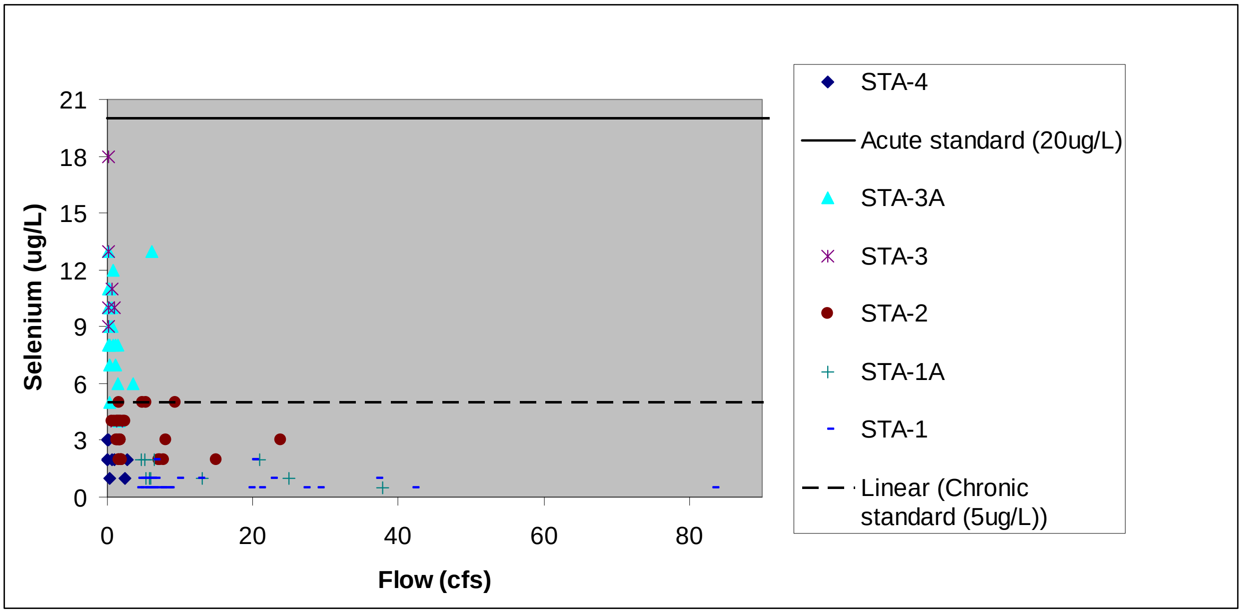


Figure 7-3. Selenium sample data at various USFS sites relative to the aquatic life standard.

Table 7-10. Summary of German Gulch selenium data relative to the water quality standard.
Bold denotes water quality target exceedances.

Flow Conditions	N	Chronic Exceedances	Acute Exceedances	Concentration Range (µg/L)
All	140	**38**	0	<1 - 18
High flow	46	**10**	0	<1 - 13
Low flow	94	**28**	0	<1 - 18

Table 7-11. Sediment metals concentrations in German Gulch.
Bold denotes a supplemental indicator value exceedance.

Site Name	Description	Se (ug/g)	As (ug/g)
GRM-01	Downstream of mine, above confluence with Greenland Gulch	**11.7**	**62.7**
GRM-02	Greenland Gulch tributary	1.1	**18.7**
GRM-03	Just upstream of confluence with Beefstraight Creek	**6.8**	**51.5**
GRM-04	At the mouth of canyon on MT FWP land	**5.3**	**36.1**
GRM-05	At Durant	**3.1**	**47.5**

Comparison to Water Quality Targets and TMDL Development Determination

Selenium

There were no exceedances of the acute aquatic life standard but 27 percent of samples exceeded the chronic aquatic life standard for selenium (**Table 7-10**). Because intensive post mine closure sampling was conducted in 2003, almost half of the samples were collected in 2003. USFS sample data with corresponding flow measurements were plotted to help assess if target exceedances exhibit a flow-related trend (**Figure 7-3**). In general, most exceedances occurred at low flows, and most target exceedances occurred at sites STA-3 and STA-3A, which are just downstream of the mine. Of the recent water samples collected by DEQ, the only sample not meeting the target was collected during low flow at a site just downstream of the mine (GRM-01). Four of the five sediment samples do not meet the supplemental indicator criteria; the sample closest to the mine had the highest concentration and was almost three times the PEL (**Table 7-11**). Based on the target and supplemental indicator exceedances, a selenium TMDL will be developed for German Gulch.

Cyanide and Arsenic

In a review of sample data for other metals, there were also target exceedances for cyanide and arsenic. A summary of sample data is presented in **Table 7-12**.

Table 7-12. Summary of German Gulch cyanide and arsenic data relative to water quality standards.

Bold denotes water quality target exceedances

Metal	Flow Conditions	N	Human Health Exceedances	Chronic Exceedances	Acute Exceedances	Concentration Range (µg/L)
Cyanide	All	118	0	**46**	**2**	<5 - 41
	High flow	34	0	**10**	**1**	<5 – 34
	Low flow	84	0	**34**	**1**	<5 - 41
Arsenic	All	50	**6**	0	0	<3 - 15
	High flow	20	**1**	0	0	<3 - 14
	Low flow	30	**5**	0	0	<3 - 15

For cyanide, 41 percent of samples exceeded the target, including two samples that exceeded the acute aquatic life standard. Most of the target exceedances occurred at low flow at sites STA-3A (immediately downstream of the mine) and STA-1 (downstream of Beefstraight Creek) (**Figure A-23**). All background samples collected in the 1980s and between 2003 and 2008 were below the detection limit for total cyanide (i.e. 10µg/L for 1980s samples and 5µg/L for recent samples). Based on the target exceedances and identified anthropogenic source, a cyanide TMDL will be developed for German Gulch.

For arsenic, six out of 53 samples exceeded the human health standard. All exceedances were in 2003 and 2004, all but one occurred at low flow, and all occurred at sites STA-3 and STA-3A (immediately downstream of the mine) (**Figure A-23**). Although there have been no observed water quality exceedances of the arsenic human health standard since 2004, all recent sediment samples exceeded the supplemental indicator value for arsenic (**Table 7-11**). The tributary sediment sample from Greenland Gulch (GRM-02), which is just above the PEL value, likely represents a background sediment concentration; all other sediment samples were at least more than two times the PEL. Baseline arsenic concentrations at STA-4 in 1987 were less than the detection limit (5µg/L) and samples collected at STA-4 in 2003/2004 were all equal to or less than 4µg/L (n=5), indicating elevated arsenic concentrations in the water column and sediment are attributable to historical mining. Based on the target and supplemental indicator exceedances, and an identified anthropogenic source, an arsenic TMDL will be developed for German Gulch.

7.4.4.5 Gold Creek, Upper Segment (MT76G005_091)

The upper segment of Gold Creek (**Figure A-25**) was listed for lead on the 2008 303(d) List. It extends 8 miles from the headwaters to the USFS boundary.

Sources and Available Data

Gold Creek was the location of the first gold discovery in Montana and the upper watershed has close to 30 abandoned mines indicated in the DEQ and MBMG databases (**Figure A-25**). None of the mines have been identified as high priority abandoned mines but agency assessment information indicates several of the mines have discharging adits and/or waste rock dumps near Gold Creek or one of its tributaries. During an assessment of abandoned mines on or near USFS land in the early 1990s, five abandoned mines within the upper Gold Creek watershed were identified as posing potential environmental risks and water samples were collected (Madison et al., 1998). One mine, Sunlight/Copper Queen is near the headwaters to Gold Creek and the rest of the potentially hazardous mines are near South Gold Creek. At the mines identified within the DEQ database, no water samples have been collected and no discharging adits were noted in the assessment files, but four abandoned mines close to either Gold Creek or South Gold Creek were identified as having tailings ponds, unstable waste rock dumps, or tailings in the floodplain.

Gold Creek was originally listed based on an elevated sample at a USFS site in the 1970s. More recently, water samples were collected during high and low flow and sediment samples were collected by DEQ at two sites in 2007/2008 (**Figure A-25**; **Table 7-13**). Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented in **Table 7-13**.

Table 7-13. Lead water quality and sediment data for the upper segment of Gold Creek.

Bold denotes a water quality target or supplemental indicator value exceedance and "--" indicates no data.

Sample Site	Location	Sample Date	Flow (cfs)	Hardness (mg/L as CaCO3)	Pb in Water Column (µg/L)	Pb in Sediment (ug/g)
GLD-03	North Fork Gold Creek	9/5/2007	1.82	78.9	< .5	18.8
GLD-04	Gold Creek upstream of North Fork	9/5/2007	3.54	65.9	< .5	19.9
GLD-03	North Fork Gold Creek	5/20/2008	22.86	30	< .5	--
GLD-04	Gold Creek upstream of North Fork	5/20/2008	39.59	42	< .5	--

Comparison to Water Quality Targets and TMDL Development Determination

Lead

None of the water samples exceeded the water quality target for lead and neither of the sediment samples exceeded the supplemental indicator value for lead. However, Ophir Mine, which is near South Gold Creek, had a small unnamed stream flowing through waste rock at the site, and the stream had a dissolved lead concentration of 3.8µg/L. That concentration would be a target exceedance at any hardness less than 115 mg/L; the measured values in upper Gold Creek during low flow were 65 and 78 mg/L (**Table 7-13**). None of the other mines that had water samples collected exceeded the lead water quality target, but soil samples along the waste rock dump that is adjacent to Gold Creek at the Sunlight-Copper Queen Mine exceeded phytotoxic concentrations for lead (Madison et al., 1998). Although there are no recent target or supplemental indicator exceedances for lead, the dataset is very limited and is not necessarily representative of water quality in the upper segment of Gold Creek. Abandoned mine data suggests there are numerous anthropogenic sources in the upper watershed that could contribute to exceedances of the lead water quality target, particularly during high flow; therefore, a lead TMDL will be developed for the upper segment of Gold Creek. Additional monitoring is recommended to better characterize water quality and refine the source assessment for upper Gold Creek.

7.4.4.6 Gold Creek, Lower Segment (MT76G005_092)

The lower segment of Gold Creek (**Figure A-25**) was not listed for any metals on the 2008 303(d) List but is included in this section because of water quality target exceedances in samples collected to aid in TMDL development. It extends from the USFS boundary to its mouth at the Clark Fork River.

Sources and Available Data

There are no priority abandoned mines in the watershed, but the DEQ and MBMG databases indicate approximately 60 abandoned mines in the lower Gold Creek watershed, in addition to the 30 abandoned mines in the upper watershed (**Figure A-25**). Most of the abandoned mines are in the upper part of the Pikes Peak Creek drainage, which starts in the upper watershed but does not flow into Gold Creek until the lower segment. During an assessment of abandoned mines on or near USFS land in the early 1990s, three abandoned mines within the upper Pikes Peak Creek drainage were identified as posing potential environmental risks and water samples were collected (Madison et al., 1998). Much of lower Gold Creek and its tributaries have been extensively placer mined, and most of the abandoned mines in the lower watershed that are not near Pikes Peak Creek are abandoned placer mines.

During sampling to assist with TMDL development, sediment samples were collected and high and low flow water samples were collected by DEQ in 2007/2008 (**Figure A-25**; **Table 7-14**). Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented in **Tables 7-14**.

Table 7-14. Lead water quality and sediment data for the lower segment of Gold Creek.
Bold denotes a water quality target or supplemental indicator value exceedance and “--" indicates no data.

Sample Site	Location	Sample Date	Flow (cfs)	Hardness (mg/L as CaCO3)	Water column (µg/L)		Sediment (ug/g)	
					Fe	Pb	Fe	Pb
GLD-05	Downstream of Crevice Creek	9/6/2007	12.12	86.9	< 50	< .5	21100	18.4
GLD-06	Blum Creek Tributary	9/6/2007	0.75	186	**1130**	0.9	18800	16
GLD-08	Pikes Peak Creek Tributary	9/6/2007	0.44	316	< 50	< .5	17500	13.2
GLD-09	Near mouth	9/6/2007	6.89	267	70	< .5	18400	13
GLD-05	Downstream of Crevice Creek	5/23/2008	79.3	41	330	< .5	--	--
GLD-06	Blum Creek Tributary	5/23/2008	5.61	92.5	**5480**	**5.4**	--	--
GLD-08	Pikes Peak Creek Tributary	5/23/2008	4.4	191	70	< .5	--	--
GLD-09	Near mouth	5/23/2008	87.17	99	**1400**	1.4	--	--

Comparison to Water Quality Targets and TMDL Development Determination

Iron and Lead

A high flow sample near the mouth (GLD-09) and high and low flow samples on the tributary of Blum Creek (GLD-06) exceeded the target value for iron. Although there is no supplemental indicator value for iron in sediment, the sediment concentrations were reviewed to determine if there are any spatial trends. The Blum Creek water sample was more than five times greater than the chronic aquatic life standard, however, the sediment iron concentration at GLD-06 was similar to all other sites and suggests the target exceedances on Blum Creek are associated with an upstream source that is getting flushed through and not associated with in-stream sediment.

None of the mines near Pikes Peak Creek that were sampled had elevated iron concentrations, which is consistent with the low concentrations measured at the mouth of Pikes Peak Creek (GLD-08). Although additional monitoring needs to be done to better characterize the source(s) of the exceedances, the extent of placer and other mining in the lower watershed combined with much lower iron concentrations in the upper part of the segment indicates the target exceedances are associated with anthropogenic sources. Based on the target exceedances in the tributary and at the mouth, an iron TMDL will be developed for the lower segment of Gold Creek.

During high flow, a sample on the tributary of Blum Creek (GLD-06) exceeded the target value for lead. All sediment concentrations were less than the supplemental indicator value for lead. At the mines that had water samples collected in upper Pikes Peak Creek, no surface water quality issues were observed, but waste rock at one mine had an elevated lead concentration and adit discharge and a flooded shaft at another mine had elevated dissolved lead concentrations. Lead concentrations at the mouth of Pikes Peak Creek (GLD-08) were below the detection limit during both sampling events, however, the dataset is limited and not necessarily representative of water quality in Pikes Peak Creek. Although the target exceedance occurred on the tributary of Blum Creek, it is a source of lead to Gold Creek and combined with other abandoned mine sources in the watershed, could contribute to target exceedances in lower Gold Creek. Therefore, a lead TMDL will be developed for the lower segment of Gold Creek. Additional monitoring is recommended to better characterize water quality and refine the source assessment for lower Gold Creek.

7.4.4.7 Lost Creek, Lower Segment (MT76G002_072)

The lower segment of Lost Creek (**Figure A-26**) was listed for arsenic, iron, manganese, and sulfates on the 2008 303(d) List. The lower segment extends 15.9 miles from the Lost Creek State Park boundary to the mouth at the Clark Fork River. The upper segment is not listed for metals.

Sources and Available Data

There are no priority abandoned mines in the Lost Creek watershed. The DEQ and MBMG databases identify approximately 25 abandoned mines in the watershed, with the majority of them located near or upstream of the Lost Creek State Park boundary (**Figure A-26**). Several of the abandoned mines are listed as recreational and none of them are identified in the assessment inventory as having discharging adits or tailings within the floodplain. A portion of the lower segment is located within the Anaconda Smelter Superfund Site, which has been documented as having widespread soil contamination as a result of atmospheric deposition from the Anaconda Smelter and other historical smelters, ground water contamination, and historical mining wastes adjacent to numerous water bodies, including Lost Creek (EPA and DEQ, 1998). The primary constituents of concern (COCs) within the Superfund Site are arsenic, cadmium, copper, lead, and zinc. The lower segment of Lost Creek gains flow from ground water and also from Gardiner Ditch, which withdraws from Warm Springs Creek (**Figure A-26**). A source assessment study conducted in 1993 as part of the Anaconda Smelter Superfund Site RI concluded that Gardiner Ditch has a “minimal impact on metals concentrations within Lost Creek” (Environmental Science and Engineering, Inc., 1995).

The sulfate listing is based on data from the late 1970s and the remaining metals listings are based on USGS data collected in 1996. Arsenic and iron were listed because of exceedances of the human health standard. However, manganese was listed because the concentration exceeded the secondary maximum contaminant level (50µg/L), which is based on aesthetic properties, and sulfate was listed because of an increase in the concentration by an order of magnitude between the upper and lower segment to 188mg/L.

The most recent sulfate data was collected between May and July 1993 as part of the RI. The sulfate concentrations ranged in value from 6.8 to 189mg/L (n=39). As part of the RI and follow-up work to fill data gaps, samples have been collected from Lost Creek and analyzed for the COCs at four primary locations (**Figure A-26**; LC-2 to LC-5) under various hydrologic conditions (**Table 7-15**). Data associated with the RI will be summarized within this section but raw data are contained within a series of Superfund-related reports (ARCO, 2002b; Pioneer Technical Services, Inc., 2003; Pioneer Technical Services, Inc., 2004). Other recent data has been collected by both USGS and DEQ. The USGS data consists of 80 samples collected since 2003 at the gage station near Anaconda (#12323840, n=30) and at the gage near Galen (#12323850, n=50) (**Figure A-26**). Data from the gaging stations are summarized in **Table 7-16** for all listed metals and any other metals with target exceedances. The DEQ data includes sediment samples and high and low flow water samples collected by DEQ in 2007/2008 at four sites (**Figure A-26**, **Tables 7-17** and **7-18**). Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented in **Tables 7-17** and **7-18**.

Table 7-15. Hydrologic distribution of sample data collected on Lost Creek as part of the Anaconda Smelter Superfund Site Remedial Investigation.

Event Type	**Sample Dates**
Low Flow	April/July 1993, March 1999
High Flow	May/June 1993
Storm-event	June 1993, July 2001, July-September 2002

Table 7-16. Summary of USGS gage data for Lost Creek relative to water quality targets.
Bold denotes water quality target exceedances.

Metal	**Gage**	**n**	**Human Health Exceedances**	**Chronic Exceedances**	**Acute Exceedances**	**Median (µg/L)**	**Concentration Range (µg/L)**
Arsenic	Anaconda	30	4	0	0	4.1	2.0 – 11.7
	Galen	50	37	0	0	12.7	6.1 – 43.0
Copper	Anaconda	30	0	6	4	4.2	1.7 – 24.1
	Galen	50	0	0	0	4.5	1.6 – 22.5
Iron	Anaconda	30	N/A[1]	0	N/A	89.5	22 - 645
	Galen	50	N/A[1]	0	N/A	74	14 - 293
Lead	Anaconda	30	0	2	0	0.3	0.1 – 2.76
	Galen	50	0	0	0	0.15	0.04 – 1.3
Manganese	Anaconda	30	0[1]	N/A	N/A	3.6	1.2 – 18.1
	Galen	50	1[1]	N/A	N/A	14.5	2.2 – 56.5

[1] The human health standard is a Secondary Maximum Contaminant Level associated with aesthetic properties and only impairs the drinking water beneficial use if it cannot be removed via conventional treatment

Table 7-17. DEQ metals data for Lost Creek.
Values in bold indicate a target exceedance.

Sample Site	Location	Sample Date	Flow (cfs)	Hardness (mg/L as CaCO3)	Total Recoverable Metal in Water Column (µg/L)				
					As	Cu	Fe	Pb	Mn
LST-01	Downstream of Lost Creek State Park	9/7/2007	4.71	88.7	<3	<1	<50	<0.5	<10
LST-04	Upstream of Galen Hwy bridge	9/4/2007	3.48	109	6	5	100	<0.5	<10
LST-06	2.6 miles upstream of I-90	9/7/2007	14.09	373	8	3	<50	<0.5	10
LST-07	Near mouth	8/31/2007	3.25	275	6	3	<50	<0.5	<10
LST-01	Downstream of Lost Creek State Park	5/29/2008	23.4	58	<3	2	140	<0.5	<10
LST-04	Upstream of Galen Hwy bridge	5/29/2008	12	82	4	**8**	220	0.9	7
LST-06	2.6 miles upstream of I-90	5/29/2008	13.51	418	**11**	4	100	0.3	40
LST-07	Near mouth	5/29/2008	34	399	**18**	4	110	0.2	40

Table 7-18. Sediment metals concentrations (ug/g dry weight) for Lost Creek.
Bold denotes a supplemental indicator value exceedance.

Sample Site	Sample Date	As	Cu	Pb
LST-01	9/7/2007	**19.1**	88.3	26.7
LST-04	9/4/2007	**40.4**	**483**	74.0
LST-06	9/7/2007	**92.1**	**520**	72.6
LST-07	8/31/2007	**48.4**	**439**	60.4

Comparison to Water Quality Targets and TMDL Development Determination

Sulfate

Two of the 1993 samples are slightly outside of the reference range for B-1 streams in Montana (i.e. 1.5 – 158mg/L), but all of the values are less than the water quality target. Although sulfate concentrations at Superfund sites LC-4 and LC-5 are an order of magnitude greater than those at LC-2 (**Figure A-26**), and are likely associated with historical mining, they are less than the target, which is associated with the lowest observed effects level for salmonids. Therefore, based on the available data, sulfate concentrations in Lost Creek are not likely to be affecting beneficial uses and no TMDL will be written for sulfate. Because the most recent data is from 1993, additional monitoring is recommended to help further characterize sulfate concentrations in Lost Creek.

Arsenic

Two of the eight DEQ samples and 41 of the USGS samples exceeded the arsenic target. Numerous samples collected at all of the Superfund sites also exceeded the water quality target for arsenic. Target exceedances occurred during all hydrological conditions but were primarily associated with high flow and storm events. The greatest arsenic concentrations occurred between site LC-2 (near the Anaconda gage) and the mouth of Lost Creek. All sediment samples exceeded the supplemental indicator value; the sample at the most upstream site (LST-01) was barely above the supplemental indicator value and likely represents the naturally occurring concentration, but samples from all other sites exceeded it by two to five times. Based on the target and supplemental indicator value exceedances, an arsenic TMDL will be developed for the lower segment of Lost Creek.

Iron and Manganese

Out of 88 samples, there were no samples that exceeded the water quality target for iron, and the highest concentration was 35 percent less than the target. For manganese, all but one sample was less than the Secondary Maximum Contaminant Level (50µg/L). The greatest manganese concentration was 56.5µg/L, which is well within the removal capacity of conventional treatment for drinking water. All recent data indicate that iron and manganese are not present in Lost Creek at concentrations that will harm beneficial uses, and no TMDL will be developed for iron or manganese.

Copper and Lead

Although Lost Creek is not listed for copper or lead, there were target exceedances for both metals. One high flow sample at DEQ site LST-04 slightly exceeded the copper water quality target, and at the nearby USGS gage near Anaconda, six samples exceeded the copper target during high flow, including four that exceeded the acute aquatic life standard. Three high flow samples at Superfund site LC-2 near the Anaconda gage exceeded the water quality target, including two that exceeded the acute aquatic life standard. During storm event sampling in 2001, target exceedances occurred at several short-term sites in the upper part of the segment and at LC-2. During storm event sampling in 1993 and 2002, target exceedances occurred at LC-2 and a single exceedance occurred near the Galen gage at LC-5. Overall, sample concentrations were greatest during storm events. For sediment, samples at three sites exceeded the supplemental indicator value and were more than twice the PEL. Based on the target and supplemental indicator exceedances, a copper TMDL will be developed for the lower segment of Lost Creek.

Two of USGS samples at the gage near Anaconda exceeded the lead water quality target during high flow and several storm event samples at Superfund site LC-2 exceeded the lead target. Similar to copper, sample concentrations were greatest during storm events. None of the sediment samples exceeded the supplemental indicator value for lead. However, based on the water quality target exceedances, a lead TMDL will be developed for the lower segment of Lost Creek.

7.4.4.8 Mill Creek, Upper Segment (MT76G002_051)

The upper segment of Mill Creek (**Figure A-27**) was listed for arsenic, cadmium, chromium, copper, lead, and zinc on the 2008 303(d) List. It flows 11 miles from its headwaters above Miller Lake to the border between Section 27 and 28.

Sources and Available Data

The abandoned mine databases only indicate one abandoned mine in the upper Mill Creek watershed and it is a mineral prospect, which is not close to any water bodies and unlikely to contribute to metals impairment. However, most of Mill Creek flows through the Anaconda Smelter Superfund Site and the 1998 ROD noted that Mill Creek is a surface water area of concern as a result of soil and ground water contamination because of aerial deposition (EPA and DEQ, 1998). The primary COCs within the Superfund Site are arsenic, cadmium, copper, lead, and zinc.

The metals listings are based on water and stream sediment data collected in the 1970s and 1980s. More recently, samples have been collected from the upper segment of Mill Creek as part of the Superfund RI and follow-up work to fill data gaps. Samples were analyzed for the COCs at one primary location (MC-5; **Figure A-27**) under various hydrologic conditions (**Table 7-19**). Data associated with the RI will be summarized within this section but raw data are contained within a series of Superfund-related reports (Pioneer Technical Services, Inc., 2002; Pioneer Technical Services, Inc., 2004). DEQ collected a sediment sample and low flow water sample at one site in 2004 (C01MILLC02) and a high flow water sample in 2008 at another site (MLL-01) (**Figure A-27**, **Table 7-20**). Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented in **Table 7-20**.

Table 7-19. Hydrologic distribution of recent sample data collected on upper Mill Creek as part of the Anaconda Smelter Superfund Site RI.

Event Type	**Sample Dates**
Low Flow	November 1999
High Flow	June 1999
Storm-event	August-September 2002

Table 7-20. Metals data for upper Mill Creek.
Bold denotes a water quality target exceedance.

Sample Site	**Location**	**Sample Date**	**Flow (cfs)**	**Hardness (mg/L as CaCO3)**	**Total Recoverable Metal in Water Column (µg/L)**					
					As	**Cd**	**Cr**	**Cu**	**Pb**	**Zn**
MC-5	D/s end of segment	6/11/1999	68.93	28.9	1.8	**0.16**	--	2.6	**0.8**	**95.8**
MC-5	D/s end of segment	11/2/1999	5.51	76.3	2.3	0.095	--	<1.5	1.1	9.7
C01MILLC02	Upper Mill Creek	7/14/2004	15.62	23	<3	<.1	<1	<1	<.5	<10
MLL-01	D/s end of segment	5/28/2008	77.75	30	<3	<.08	2	3	<.5	<10
Sample Site	**Location**	**Sample Date**			**Sediment Metals Concentrations (ug/g dry weight)**					
C01MILLC02	Upper Mill Creek	7/14/2004			<12	<0.5	52.3	42.3	26	99

Comparison to Water Quality Targets and TMDL Development Determination

Arsenic

None of the high or low flow samples exceeded the arsenic water quality target but one storm event sample at MC-5 exceeded the water quality target. The sediment sample met the arsenic supplemental indicator value. However, based on the target exceedance and that historical atmospheric deposition from the Anaconda Smelter has been identified as a source, an arsenic TMDL will be developed for the upper segment of Mill Creek.

Cadmium
One high flow sample and three storm event samples at MC-5 exceeded the cadmium water quality target. There was blank contamination in the high flow sampling run, but based on the storm event water quality target exceedances, the elevated high flow concentration is likely valid. The sediment sample met the cadmium supplemental indicator value. However, based on the target exceedances and that historical atmospheric deposition from the Anaconda Smelter has been identified as a source, a cadmium TMDL will be developed for the upper segment of Mill Creek.

Chromium
None of the samples exceeded the water quality target for chromium and the sediment sample is well below the supplemental indicator value for chromium. Because chromium is not a primary COC for the Superfund, no samples at MC-5 were analyzed for chromium. Based on all samples meeting the target and supplemental indicator values, no TMDL will be developed for chromium. Because exceedances for other metals occurred during high flow and storm events, additional monitoring for chromium is recommended, particularly during high flow and storm events.

Copper
Three storm event samples at MC-5 exceeded the copper water quality target. The sediment sample met the copper supplemental indicator value. However, based on the target exceedances and that historical atmospheric deposition from the Anaconda Smelter has been identified as a source, a copper TMDL will be developed for the upper segment of Mill Creek.

Lead
One high flow sample and three storm event samples at MC-5 exceeded the lead water quality target. The sediment sample met the lead supplemental indicator value. However, based on the target exceedances and that historical atmospheric deposition from the Anaconda Smelter has been identified as a source, a lead TMDL will be developed for the upper segment of Mill Creek.

Zinc
One high flow sample and two storm event samples at MC-5 exceeded the zinc water quality target. There was blank contamination in the high flow sampling run, but based on the storm event water quality target exceedances, the elevated high flow concentration is likely valid. The sediment sample met the zinc supplemental indicator value. However, based on the target exceedances and that historical atmospheric deposition from the Anaconda Smelter has been identified as a source, a zinc TMDL will be developed for the upper segment of Mill Creek.

7.4.4.9 Mill Creek, Lower Segment (MT76G002_052)

The lower segment of Mill Creek (**Figure A-27**) was listed for aluminum, arsenic, cadmium, copper, iron, lead, and zinc on the 2008 303(d) List. It flows 8.7 miles from the border between Section 27 and 28 to its mouth at the Mill-Willow Bypass. Mill Creek historically flowed directly into Silver Bow Creek but its flow is now combined with that of Willow Creek into the Mill-Willow Bypass to route water around the Warm Springs Ponds, which serve as treatment ponds for Silver Bow Creek.

Sources and Available Data

There are no priority abandoned mines within the watershed, but the abandoned mine databases indicate several abandoned mines along the lower segment of Mill Creek and its tributaries (**Figure A-27**). Most of the abandoned mines are near Smelter Hill, where the Anaconda Smelter was located. In a review of mine inventory information, no discharging adits were noted and two of the mines along Silver Creek, which is near Smelter Hill, each had approximately 0.5 acres of unvegetated tailings. Most of Mill Creek flows through the Anaconda Smelter Superfund Site. Aerial deposition from the Anaconda Smelter and resulting soil and ground water contamination is mentioned in the 1998 ROD as the primary source of metals to Mill Creek, but inputs from streamside wastes are also noted (EPA and DEQ, 1998). The primary COCs within the Superfund Site are arsenic, cadmium, copper, lead, and zinc.

Metals listings are based on water and stream sediment data from the 1970s and mid-1990s. More recently, samples have been collected as part of the RI and follow-up work to fill data gaps from the upper segment of Mill Creek and analyzed for the COCs at four primary locations (**Figure A-27**; MC-7, MC-7A, MC-8, MC-10A) under various hydrologic conditions (**Table 7-21**). Tributary storm event samples were collected on Muddy Creek (MCT-0), Ceonothus Creek (CC-6), Joyner Creek (MCT-4), and on Cabbage Gulch (CG-2, CG-5), which are near the perimeter of the Mount Haggin Wildlife Management Area (referred to hereafter as Mount Haggin) (**Figure A-27**). Mount Haggin has been identified as an upland area with elevated metals concentrations in the soil and ground water because of atmospheric deposition from the Anaconda Smelter (EPA and DEQ, 1998). High and low flow samples were also collected on tributaries originating on both Mount Haggin and Smelter Hill (**Figure A-27**). Data associated with the RI will be summarized within this section but raw data are contained within a series of Superfund-related reports (Pioneer Technical Services, Inc., 2002; Pioneer Technical Services, Inc., 2004). Other recent data has been collected by both USGS and DEQ. The USGS data consists of 73 samples collected since 2003 at the gage station near Anaconda (#12323670, n=29) and at the gage at Opportunity (#12323700, n=44) (**Figure A-27**). Data from the gaging stations are summarized in **Table 7-22** for all listed metals and any other metals with target exceedances. Diurnal samples The DEQ data includes sediment samples and high and low flow water samples collected by DEQ in 2007/2008 at four sites (**Figure A-27**, **Tables 7-23** and **7-24**). Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented in **Tables 7-23** and **7-24**.

Table 7-21. Hydrologic distribution of recent sample data collected on Mill Creek as part of the Anaconda Smelter Superfund Site Remedial Investigation.

Event Type	**Sample Dates**
Low Flow	March 1999
High Flow	June 1999
Storm-event	July 2001, July-September 2002

Table 7-22. Summary of USGS gage data for Mill Creek relative to water quality targets. Bold denotes water quality target exceedances.

Metal	Gage	n	Human Health Exceedances	Chronic Exceedances	Acute Exceedances	Median (µg/L)	Concentration Range (µg/L)
Arsenic	Anaconda	29	**27**	0	0	16.6	9 – 30.1
	Opportunity	44	**43**	0	0	25.1	10 – 50
Cadmium	Anaconda	29	0	**1**	0	0.06	0.04 – 0.18
	Opportunity	44	0	**9**	**1**	0.11	0.04 – 0.85
Copper	Anaconda	29	0	**9**	**5**	2.9	1.3 – 10.3
	Opportunity	44	0	**19**	**14**	3.85	1.5 – 38.8
Iron	Anaconda	29	N/A[1]	0	N/A	166	89 - 619
	Opportunity	44	N/A[1]	**3**	N/A	131	44 - 1960
Lead	Anaconda	29	0	**5**	0	0.56	0.19 – 3.12
	Opportunity	44	0	**13**	0	0.35	0.07 – 12.7
Zinc	Anaconda	29	0	0	0	2.0	1 - 8
	Opportunity	44	0	0	0	3.2	2 - 41

[1] The human health standard is a Secondary Maximum Contaminant Level associated with aesthetic properties and the water quality target is based on the aquatic life standard.

Table 7-23. Metals data for lower Mill Creek. Bold denotes water quality target exceedances.

Sample Site	Location	Sample Date	Flow (cfs)	Hardness (mg/L as $CaCO^3$)	Total Recoverable Metal in Water Column (µg/L)[1]						
					Al	As	Cd	Cu	Fe	Pb	Zn
C01MIL LC01	Downstream of Joyner Creek	7/13/2004	45.31	46	<100	4	<.1	1	40	<5	<10
MLL-02	Unnamed trib at upper end of segment	8/27/2007	3.04	129	<30	8	<.08	1	70	<5	<10
MLL-03	Upstream of Silver Ck. Tributary	8/27/2007	8.81	84.9	<30	12	<.08	2	110	0.5	<10
MLL-04	Downstream of Clear Creek	8/27/2007	10.01	81	<30	17	<.08	2	180	<5	<10
MLL-05	Downstream of Anaconda gage	8/27/2007	10.1	82.9	<30	27	<.08	3	200	<5	<10
MLL-06	Near mouth	8/28/2007	0.59	87.3	<30	28	<.08	2	<50	<5	<10
MLL-02	Unnamed trib at upper end of segment	5/28/2008	30	56	50	26	<.08	7	470	1.6	<10
MLL-03	Upstream of Silver Ck. Tributary	5/28/2008	117.49	41	70	11	<.08	5	260	0.8	<10
MLL-04	Downstream of Clear Creek	5/28/2008	123	38	70	17	<.08	5	280	0.8	<10
MLL-05	Downstream of Anaconda gage	5/28/2008	120	48	80	26	0.1	6	240	1	10
MLL-06	Near mouth	5/28/2008	64	42	80	30	<.08	9	250	1.5	<10

[1] Aluminum concentrations are dissolved as the Montana water quality standard applies to the dissolved fraction.

Table 7-24. Sediment metals concentrations (ug/g dry weight) for lower Mill Creek.
Values in bold indicate a supplemental indicator value exceedance.

Sample Site	Location	Sample Date	As	Cd	Cu	Pb	Zn
MLL-02	Unnamed trib at upper end of segment	8/27/2007	**85.5**	2.29	**356**	**130**	**428**
MLL-03	Upstream of Silver Ck. Tributary	8/27/2007	**128**	**4.22**	**382**	**142**	**419**
MLL-04	Downstream of Clear Creek	8/27/2007	**373**	**3.7**	**454**	**126**	**401**
MLL-05	Downstream of Anaconda gage	8/27/2007	**204**	**4.84**	**376**	**128**	**330**
MLL-06	Near mouth	8/28/2007	**392**	**7.28**	**543**	**151**	**487**

Comparison to Water Quality Targets and TMDL Development Determination

Aluminum

The detection limit for the 2004 sample was slightly greater than the water quality target (i.e. chronic standard = 87µg/L), but the sample was below the detection limit, and all other samples were less than the aluminum water quality target. The detection limit during the early 1970s was 500 or 1000µg/L, and the measured concentrations near the mouth ranged from below detection to 3,000 or 4,000µg/L, with one sample having a concentration of 73,000µg/L. The current range of concentrations is from less than 30µg/L to 80µg/L, which is similar to recently measured concentrations in other streams in the Upper Clark Fork TPA. Additionally, the concentrations varied little from the upper segment of Mill Creek (MLL-01), where atmospheric deposition is the major source of metals, to the lower segment, where abandoned mines, streamside wastes, and atmospheric deposition are all potential sources. The substantial decrease between historical and recent dissolved aluminum concentrations and the fact that none of the recent data exceed the water quality target indicates that historical sources of aluminum have been addressed and that recent concentrations likely represent the background concentration. Therefore, no aluminum TMDL will be developed for the lower segment of Mill Creek. However, because the number of recent samples is limited, additional monitoring is recommended during both high and low flow.

Arsenic

The majority of samples at both USGS gages exceeded the arsenic water quality target, and all DEQ samples exceeded the target except for the uppermost sites during low flow. Additionally, the target was exceeded at all Superfund sites during all high flow, low flow, and storm events. In general, there is a slight downstream increase in concentration, with the most noticeable increase between sites MC-7 and MC-7A at all flows. There were also numerous target exceedances at the tributary sites at all flows, and tributary concentrations tended to be greater than in Mill Creek, particularly in Cabbage Gulch and tributaries originating on Smelter Hill. All sediment samples exceeded the supplemental indicator value for arsenic and values ranged from 5 to 23 times greater than the PEL, with the greatest concentration occurring near the mouth (MLL-06). Based on the target and supplemental indicator value exceedances, an arsenic TMDL will be developed for the lower segment of Mill Creek.

Cadmium

There was one exceedance of the cadmium water quality target at the Anaconda gage and nine target exceedances at the Opportunity gage, including one exceedance of the acute water quality standard. None of the DEQ samples exceeded the water quality target, but at the Superfund sites, there were numerous target exceedances at all sites during storm event sampling and at all sites except MC-7 during high flow. There was blank contamination in the high flow sampling run, but based on the numerous other water quality target exceedances, the elevated high flow concentration is likely valid. At the tributary sites, there were exceedances during all sampling events and concentrations were typically greater than in Mill Creek. Although tributary samples exceeded the water quality target at low flow, target exceedances in Mill Creek were all associated with either a storm event or high flow. Sediment concentrations exceeded the supplemental indicator value for cadmium at all sites except the uppermost site (MLL-02) and the greatest concentration was near the mouth (MLL-06) and more than double the PEL. Based on the target and supplemental indicator value exceedances, a cadmium TMDL will be developed for the lower segment of Mill Creek.

Copper

There were nine exceedances of the copper water quality target at the Anaconda gage and 19 target exceedances at the Opportunity gage; More than half of all target exceedances at each gage exceeded the acute water quality standard. Target exceedances at the gages were associated with snowmelt and high flow. At both the DEQ and Superfund sites, all samples exceeded the water quality target during high flow. During storm event sampling, there were numerous target exceedances at all sites. Samples from the tributary sites exceeded the water quality target at all flows and concentrations were typically greater than in Mill Creek. All sediment samples exceeded the supplemental indicator value for copper and values ranged from almost twice to almost three times greater than the PEL, with the greatest concentration occurring near the mouth (MLL-06). Based on the target and supplemental indicator value exceedances, a copper TMDL will be developed for the lower segment of Mill Creek.

Iron

Three of the samples at the Opportunity gage exceeded the iron water quality target. All exceedances occurred during high flow. None of the DEQ samples exceeded the water quality target. Based on the target exceedances at the Opportunity gage, an iron TMDL will be developed for the lower segment of Mill Creek.

Lead

There were five exceedances of the lead water quality target at the Anaconda gage and 13 target exceedances at the Opportunity gage. All exceedances were associated with high flow. Two high flow samples exceeded the water quality target at the uppermost and lowermost DEQ sites (MLL-02 and MLL-06). At the Superfund sites, the water quality target was exceeded at all sites during storm event sampling and at the two most downstream sites during high flow (MC-8 and MC-10A). Samples from the tributary sites exceeded the water quality target at all flows and concentrations were typically greater than in Mill Creek. All sediment samples exceeded the supplemental indicator value for lead, and although the concentration was greatest near the mouth (MLL-06), concentrations varied little from the upper part of the segment to the mouth.

Based on the target and supplemental indicator value exceedances, a lead TMDL will be developed for the lower segment of Mill Creek.

Zinc

None of the samples at the USGS gages or DEQ sites exceeded the water quality target. During storm event sampling at the Superfund sites, the water quality target was exceeded once near the mouth (MC-10A) and twice downstream of Anaconda (near MC-7A). At the tributary sites, the only target exceedances occurred during storm event sampling, and concentrations were typically greater than in Mill Creek. All sediment samples exceeded the supplemental indicator value for zinc, and although the concentration was greatest near the mouth (MLL-06), concentrations varied little from the upper part of the segment to the mouth. Based on the target and supplemental indicator value exceedances, a zinc TMDL will be developed for the lower segment of Mill Creek.

7.4.4.10 Mill-Willow Bypass (MT76G002_120)

The Mill-Willow Bypass (**Figure A-28**) was listed for arsenic, copper and lead on the 2008 303(d) List. The listed segment is currently described as flowing 4.2 miles from Silver Bow Creek to the Clark Fork River but DEQ is in the process of changing the description to more accurately reflect the origin of the bypass and to be consistent with ARM 17.30.607, which describes Silver Bow Creek as flowing "from the confluence of Blacktail Creek to Warm Springs Creek", which is the headwaters of the Clark Fork River. Prior to construction of the Warm Springs Ponds and the bypass, Mill and Willow creeks flowed into Silver Bow Creek (upstream of its confluence with Warm Springs Creek). For this document, the Mill-Willow Bypass will be considered to start at the confluence of Mill and Willow creeks near Interstate 90 and end at the outlet of Warm Springs Pond 2 where Silver Bow Creek flows out of the Warm Springs (treatment) Ponds.

Sources and Available Data

The abandoned mines databases do not indicate any abandoned mines near the Mill-Willow Bypass but there are numerous sources of historical mining wastes within its watershed. The Mill-Willow Bypass is partially within both the Anaconda Smelter and Butte-Silver Bow Superfund sites, and therefore is influenced by sources within both sites. The bypass is formed by Mill and Willow creeks, which are both on the 2008 303(d) List for various metals, but it has also received mining wastes flushed from Silver Bow Creek during periods of high flow. The primary COCs within the Superfund sites are arsenic, cadmium, copper, lead, and zinc.

The Mill-Willow Bypass was constructed in the 1960s to transport Mill and Willow creeks around the Warm Springs Ponds and also to handle floodwaters from Silver Bow Creek, including the Warm Springs Ponds (which contain historical mine tailings and treat water from Silver Bow Creek). As part of Superfund remediation efforts, over 400,000 cubic yards of tailings were removed from the bypass and meanders were added to a portion of the channel during channel reconstruction between 1990 and 1995 (EPA, 2005). Also during channel reconstruction, capacity upgrades were made to allow the Warm Springs Ponds to treat up to the 100-year flood before floodwaters are diverted to the bypass, and the bypass was modified to handle up to 70,000 cfs (i.e. half the probable maximum flow from Mill, Willow, and Silver Bow creeks) (EPA, 2005).

Along the dike that separates the bypass from the Warm Springs Ponds, there are almost 200 perforated pipe drains to relieve ground water pressure against the soil-cement layer that covers the bypass side of the dike and to maintain the stability of the dam (**Figure A-29**). Seepage along Pond 3, the uppermost pond, drains to the bypass and seepage from Pond 2 is collected in a ground water interception trench and pumped back into Pond 2 (**Figure A-29**). Both Ponds 2 and 3 are settling basins; Silver Bow Creek is limed during the fall, winter, and early spring as it enters Pond 3 to increase the pH and help metals coagulate and settle out along with suspended sediment. Only some of the drains along Pond 3 flow continuously and others flow sporadically, with flows typically ranging from 5 to 10 gallons per minute (EPA, 2000). Seepage from eleven drains that were mostly along Pond 3 and assumed to be representative of seepage water quality was sampled annually from 1999 to 2004. Concentrations of cadmium, copper, and zinc were all low or non-detectable, but arsenic averaged 66µg/L with a maximum concentration in 1999 of 145µg/L.

To help assess progress of the Superfund remediation, water samples have been collected monthly from the Mill-Willow Bypass since the mid 1990s. There is a sampling site near the beginning of the Bypass (MWB-1) and another site just upstream of the Warm Springs Pond 2 outlet (MWB-2) (**Figure A-28**). The metals listings are based on data collected in the mid-1990s prior to and after the remediation and channel reconstruction. More recent sampling data from January 2000 through August 2008 are summarized in **Table 7-25**. A review of sampling data prior to 2000 shows the same water quality trends. Note, although an entire suite of metals was sampled, only listed metals or those with target exceedances are presented in **Table 7-25**. No recent sediment samples have been collected in the bypass. There are no surface water inputs between the two sites; along the bypass, potential inputs are from ground water coming through the pipe drains and ground water coming from the Opportunity Ponds, which are adjacent to the Mill-Willow Bypass but separated by Interstate 90 (**Figure A-28**). The Opportunity Ponds contain 129.3 million cubic yards of tailings and because some of the tailings are in direct contact with the water table, they are a potential source of metals-enriched ground water to the bypass (EPA and DEQ, 1998).

Table 7-25. Summary of monthly sample data from 2000-2008 for the Mill-Willow Bypass relative to water quality targets (n = 104).

Bold denotes water quality target exceedances.

Metal	Sample Site	Human Health Exceedances	Chronic Exceedances	Acute Exceedances
Arsenic	MWB-1	**94**	0	0
	MWB-2	**95**	0	0
Cadmium	MWB-1	0	**4**	0
	MWB-2	0	0	0
Copper	MWB-1	0	**25**	**13**
	MWB-2	0	**9**	**4**
Lead	MWB-1	**1**	**9**	**1**
	MWB-2	0	**3**	0

Table 7-25. Summary of monthly sample data from 2000-2008 for the Mill-Willow Bypass relative to water quality targets (n = 104).
Bold denotes water quality target exceedances.

Metal	Sample Site	Human Health Exceedances	Chronic Exceedances	Acute Exceedances
Zinc	MWB-1	0	**2**	0
	MWB-2	0	0	0

Comparison to Water Quality Targets and TMDL Development Determination

Arsenic

In samples collected since 2000, the arsenic water quality target was exceeded 94 times at the upper site (MWB-1) and 95 times at the lower site (MWB-2). Although the target was exceeded during all months, the concentration was typically the greatest during high flow and early summer. Arsenic concentrations generally decreased or stayed the same between MWB-1 and MWB-2. Based on target exceedances, an arsenic TMDL will be developed for the Mill-Willow Bypass.

Copper

In samples collected since 2000, numerous samples at both sites exceeded the water quality target. At the upper site (MWB-1), 25 samples exceeded the chronic aquatic life standard and 13 of the exceedances were also greater than the acute aquatic life standard. At the lower site (MWB-2), 9 samples exceeded the chronic aquatic life standard and 4 of the exceedances were also greater than the acute aquatic life standard. Most target exceedances occurred during high flow and concentrations were generally slightly greater at site MWB-1. However, the greater frequency of target exceedances at MWB-1 compared to MWB-2 is associated with an increase in hardness between the sites; hardness values typically increased by 1.5 to 2 times from site MWB-1 to MWB-2 and because the water quality standard for copper is hardness-dependent, the target values during each sampling event were greater for site MWB-2 than MWB-1. Based on target exceedances, a copper TMDL will be developed for the Mill-Willow Bypass.

Lead

In samples collected since 2000, numerous samples at both sites exceeded the water quality target. At the upper site (MWB-1), 9 samples exceeded the chronic aquatic life standard and 1 of the exceedances was also greater than both the human health and acute aquatic life standards. At the lower site (MWB-2), 3 samples exceeded the chronic aquatic life standard. Most target exceedances occurred during high flow and concentrations were generally the same at both sites or slightly greater at site MWB-1. The greater frequency of target exceedances at MWB-1 compared to MWB-2 is associated with an increase in hardness between the sites; hardness values typically increased by 1.5 to 2 times from site MWB-1 to MWB-2 and because the water quality standard for copper is hardness-dependent, the target values during each sampling event were greater for site MWB-2 than MWB-1. Based on target exceedances, a lead TMDL will be developed for the Mill-Willow Bypass.

Cadmium and Zinc

In samples collected since 2000, four samples exceeded the cadmium water quality target and two samples exceeded the zinc water quality target. The cadmium exceedances occurred during winter and high flow and generally corresponded to exceedances for arsenic, copper, and lead. The zinc exceedances were greater than the acute aquatic life standard and occurred during low flow in summer and winter. All water quality target exceedances occurred at the upstream site (MWB-1), which had a lower hardness value during all sampling events. Based on target exceedances, cadmium and zinc TMDLs will be developed for the Mill-Willow Bypass.

7.4.4.11 Modesty Creek (MT76G002_080)

Modesty Creek (**Figure A-30**) was listed for arsenic on the 2008 303(d) List. Modesty Creek flows 14.1 miles from the headwaters to the mouth at the Clark Fork River.

Sources and Available Data
The abandoned mine databases indicate four abandoned mines in the Modesty Creek watershed and none of them are priority abandoned mines. In an office screening, none of the mines were identified by MBMG as posing an environmental impact (Madison et al., 1998). Although the major areas affected by atmospheric deposition from the Anaconda Smelter were identified in the 1998 ROD, the boundaries of the Superfund site are not well defined and have expanded as RI sampling indicates additional areas that have been affected. The Modesty Creek watershed is an area that RI surface and ground water sampling indicates has been affected by historic atmospheric deposition from the Anaconda Smelter and resulted in soil and ground water contamination (personal comm. C. Coover, 2009). The primary COCs within the Superfund Site are arsenic, cadmium, copper, lead, and zinc.

Modesty Creek was originally listed based on an elevated arsenic sample near the mouth in the late 1970s. More recently, high flow and storm event samples have been collected as part of the Anaconda Smelter Superfund Site RI (ARCO, 2002b; Pioneer Technical Services, Inc., 2004). Samples were collected during high flow at four sites in June 2002 (**Figure A-30**; MOD-3 to MOD-5 and MOD-10) and at one site (MOD-4) during three storm events in August and September 2002 (**Table 7-26**). Because of irrigation withdrawals in the upper watershed, there was no flow during the high flow sampling from MOD-6 to shortly upstream of MOD-10 (ARCO, 2002b; Pioneer Technical Services, Inc., 2004). Lower Modesty Creek (i.e. near MOD-10) receives irrigation returns that originated in Lost Creek, Racetrack Creek, and Warm Springs Creek (via Gardiner Ditch) and may affect water quality; samples were collected in 2002 from two of the ditches (**Table 7-26**). To aid in TMDL development, DEQ collected sediment samples and high and low flow samples at two sites in 2007/2008 (**Figure A-30**; **Tables 7-26** and **7-27**). Note, although an entire suite of metals was sampled, only listed metals or those with target exceedances are presented in **Tables 7-26** and **7-27**.

Table 7-26. Metals data for Modesty Creek.
Bold denotes water quality target exceedances and "--" indicates no data.

Sample Site	Location	Sample Date	Flow (cfs)	Hardness (mg/L as $CaCO_3$)	Total Recoverable Metals in Water Column (µg/L)			
					As	Cd	Cu	Pb
MOD-4[2]	Spring Gulch Rd and Modesty Ck Rd	8/21/2002	--	142	6.8	**0.38**	7	2.1
MOD-4[2]	Spring Gulch Rd and Modesty Ck Rd	9/6/2002	--	152	**23.3**	**0.48**	**25.5**	**9.8**

Table 7-26. Metals data for Modesty Creek.
Bold denotes water quality target exceedances and "--" indicates no data.

Sample Site	Location	Sample Date	Flow (cfs)	Hardness (mg/L as CaCO$_3$)	Total Recoverable Metals in Water Column (µg/L)			
					As	**Cd**	**Cu**	**Pb**
MOD-4[2]	Spring Gulch Rd and Modesty Ck Rd	9/17/2002	--	151	**19**	0.29	**14.8**	5.2
MOD-3	Just upstream of FS boundary	6/13/2002	1.1	147	9.7[1]	<0.06	2.8[1]	1.0[1]
MOD-4	Spring Gulch Rd and Modesty Ck Rd	6/13/2002	2.68	142	5.0[1]	<0.06	2.4[1]	0.69[1]
MOD-5	Downstream of Modesty Ck Rd crossing	6/13/2002	2.79	144	**10.3**	<0.06	5.0[1]	1.1[1]
MODT-6	Tributary ~0.25mi upstream of MOD-6	6/13/2002	1.93	154	**17.4**	<0.06	6.7[1]	1.6[1]
MOD-6	Upstream of Modesty Ck Rd and Racetrack Rd	6/13/2002	Not flowing due to irrigation withdrawals					
MOD-10	Near Galen Rd	6/13/2002	0.83	128	**18.6**	<0.06	7.6[1]	0.74[1]
MDS-03	East of Modesty Ck. Rd. and Racetrack Rd.	5/29/2008	1.78	34	<3	<.08	1	<.5
MDS-04	Near the mouth between the frontage road and I-90	5/29/2008	3.69	378	**13**	<.08	7	1
MDS-03	East of Modesty Ck. Rd. and Racetrack Rd.	8/29/2007	4.28	141	6	<.08	2	<.5
MDS-04	Near the mouth between the frontage road and I-90	8/29/2007	6.38	319	**14**	<.08	5	0.6
Measured ditch inflows to Modesty Creek between MOD-6 and MOD-10								
MOD-GD	Inflow from Gardiner Ditch	6/13/2002	4.45	91.3	**11.7**	0.11[1]	**15.61**	1.8[1]
MOD-RT	Inflow from 2 ditches from Racetrack Creek	6/13/2002	2.73	29.7	2.6[1]	<0.06	**3.4[1]**	<0.62

[1] Value is greater than the instrument detection limit but less than the contract required detection limit
[2] Sample concentrations are the maximum measured concentration for each storm event

Table 7-27. Sediment metals concentrations (ug/g dry weight) for Modesty Creek.
Bold denotes a supplemental indicator value exceedance.

Sample Site	Location	Sample Date	As	Cd	Cu	Pb
MDS-03	East of Modesty Ck. Rd. and Racetrack Rd.	8/29/2007	**30.2**	1.94	138	40.5
MDS-04	Near the mouth between the frontage road and I-90	8/29/2007	**17.6**	1.09	105	27.1

Comparison to Water Quality Targets and TMDL Development Determination

Arsenic

At the Superfund sites, two storm event samples and two high flow samples exceeded the arsenic water quality target. The arsenic water quality target was exceeded during high and low flow at the DEQ site near the mouth (MDS-04). The sample from Gardiner Ditch exceeded the water quality target, indicating the ditch may be a source of arsenic. Although Modesty Creek is heavily irrigated and the Superfund-related monitoring determined that flow near the mouth may be the result of irrigation returns from other watersheds, arsenic water quality target exceedances occurred near the mouth and upstream of the irrigation returns. Both sediment samples exceeded the supplemental indicator value for arsenic. Based on the target and supplemental indicator value exceedances, an arsenic TMDL will be developed for Modesty Creek.

Cadmium, Copper, and Lead
Although Modesty Creek is only listed for arsenic, storm event samples exceeded the water quality target for cadmium, copper, and lead. Samples from Gardiner Ditch and ditches that originate in Racetrack Creek exceeded the copper water quality target. Gardiner Ditch originates in Warm Springs Creek, which is being addressed within this document by a copper TMDL, but Racetrack Creek has no metals listings and additional sampling is recommended to assess water quality in Racktrack Creek. None of the sediment concentrations exceeded their respective supplemental indicator values. Cadmium, copper, and lead are all COCs relative to the Anaconda Smelter Superfund Site because of their association with atmospheric deposition from the Anaconda Smelter. Therefore, the water quality target exceedances during storm events are likely associated with runoff from areas with elevated soil concentrations as a result of historical atmospheric deposition and TMDLs for cadmium, copper, and lead will be developed for Modesty Creek.

7.4.4.12 Peterson Creek, Upper Segment (MT76G002_131)

The upper segment of Peterson Creek (**Figure A-31**) was listed for copper on the 2008 303(d) List. It flows 6.4 miles from the headwaters to Jack Creek.

Sources and Available Data
In the upper Peterson Creek watershed, there are no priority abandoned mines, but the abandoned mine databases indicate seven abandoned mines. The DEQ abandoned mine assessment files indicate extensive placer mining in the upper watershed, tailings at several of the sites, and springs or other surface water near five of the mines. Additionally, the upper segment has numerous beaver complexes, which, as discussed in **Section 5.0**, can be important sinks for sediment; however, if the beaver complexes are retaining metals-enriched sediment associated with historical mining, they may also periodically flush the sediment during high flow or as the structure of the beaver complexes changes.

The copper listing is based on elevated copper concentrations during sampling conducted at two sites in the upper segment in May 2002 as part of the East Valley Watershed Baseline Report (KirK Environmental, LLC, 2003). The concentration in a duplicate sample came in outside of the QC limits for copper and limits the usefulness of the measured concentrations, but the exceedance was validated with water quality samples collected by the National Park Service in 1976 that also had elevated copper concentrations. More recently, DEQ collected high and low flow water samples and also sediment samples at three sites in the upper Peterson Creek watershed in 2007/2008 (**Figure A-31**; **Tables 7-28** and **7-29**). Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented in **Tables 7-28** and **7-29**.

Table 7-28. Metals data for the upper segment of Peterson Creek.
Bold denotes a water quality target exceedance.

Sample Site	Location	Sample Date	Flow (cfs)	Hardness (mg/L as CaCO3)	Total Recoverable Metals in Water Column (µg/L)		
					Cu	Fe	Pb
PTR-01	Near the headwaters	9/4/2007	0.06	88	2	260	<.5
PTR-02	Spring Creek Tributary	9/4/2007	1.58	65	<1	80	<.5
PTR-06	Downstream of Jack Creek	9/4/2007	0.46	84	2	340	<.5
PTR-01	Near the headwaters	5/19/2008	1.07	42	**5**	720	0.9
PTR-02	Spring Creek Tributary	5/19/2008	2.19	24	2	560	<.5
PTR-06	Downstream of Jack Creek	5/19/2008	20.52	39	7	**1630**	**1.5**

Table 7-29. Sediment metals concentrations (ug/g dry weight) for Peterson Creek.
Bold denotes a supplemental indicator value exceedance.

Sample Site	Location	Sample Date	Cu	Pb
PTR-01	Near the headwaters	9/4/2007	**225**	36.8
PTR-02	Spring Creek Tributary	9/4/2007	193	35.3
PTR-06	Downstream of Jack Creek	9/4/2007	**223**	48

Comparison to Water Quality Targets and TMDL Development Determination

Copper

Two water samples during high flow exceeded the copper water quality target. Sediment samples at the same sites with the target exceedances also exceeded the supplemental indicator value for copper. Based on the target and supplemental indicator value exceedances, a copper TMDL will be developed for the upper segment of Peterson Creek.

Iron and Lead

Although the upper segment of Peterson Creek is only listed for copper, a high flow sample at the most downstream end of the segment (PTR-06) exceeded the water quality target for iron and lead. Total suspended solids (TSS) was measured at the sites and during high flow, it was slightly above the detection limit at the upper two sites but more than doubled at PTR-06, suggesting the iron and lead water quality target exceedances are associated with sediment. As discussed in **Section 5.0**, the upper segment of Peterson Creek is impaired for sediment because of anthropogenic sources and requires sediment TMDL development. During sampling in 2002, iron was not analyzed and both of the samples were less than the detection limit for lead. None of the sediment samples exceeded the supplemental indicator value for lead. However, based on the abandoned mines in the upper watershed, anthropogenic sources of excess sediment that may be related to elevated metals, and water quality target exceedances, iron and lead TMDLs will be developed for the upper segment of Peterson Creek.

7.4.4.13 Peterson Creek, Lower Segment (MT76G002_132)

The lower segment of Peterson Creek (**Figure A-31**) was not listed for any metals on the 2008 303(d) List but is included in this section because of water quality target exceedances in samples collected to aid in TMDL development. It flows 6.9 miles from Jack Creek to the mouth at the Clark Fork River.

Sources and Available Data

In the lower Peterson Creek watershed, there are no priority abandoned mines, but the abandoned mine databases indicate two abandoned mines (in addition to the seven mines in the upper watershed). One mine was a pumice mine and the other was a tailings site, but no additional information was found regarding site conditions at the mines.

Depending on how much dilution occurs from tributaries, sources within the upper segment of Peterson Creek may also be sources to the lower segment. This includes abandoned mines and sediment pulses from the beaver complexes, if they occur. Additionally, as discussed in **Section 5.0**, the upper portion of the lower segment also contains beaver complexes; if the beaver complexes are retaining metals-enriched sediment associated with historical mining, the sediment may be periodically flushed during high flow or as the structure of the beaver complexes changes.

For the East Valley Watershed Baseline Report, samples were collected in May 2002 at four sites in the lower segment of Peterson Creek, including the tributary of Burnt Hollow Creek (KirK Environmental, LLC, 2003). Also, DEQ collected sediment samples and high and low flow samples near the mouth in 2007/2008 (**Figure A-31**; **Table 7-30**). Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented in **Table 7-30**.

Table 7-30. Recent metals data for the lower segment of Peterson Creek.
Bold denotes water quality target exceedances and “--" indicates no data.

Sample Site	Location	Sample Date	Flow (cfs)	Hardness (mg/L as CaCO3)	Water column (µg/L)		Sediment (ug/g)
					As	Fe	As
PTR-14	Near mouth	9/4/2007	0.12	262	**11**	550	14.4
		5/19/2008	11.55	103	**12**	**2080**	--

Comparison to Water Quality Targets and TMDL Development Determination

Arsenic and Iron

Samples exceeded the arsenic water quality target during high and low flow. None of the samples from the upper segment exceeded the water quality target. The arsenic values from the sampling in 2002 were below the water quality target upstream of Burnt Hollow Creek, but were greater than the target in Burnt Hollow Creek and in the Peterson Creek samples downstream of Burnt Hollow Creek. The geology in upper Burnt Hollow Creek is volcanic (indicated as igneous extrusive in **Figure A-5**), which is often associated with elevated arsenic concentrations. Although other portions of the Peterson Creek watershed (e.g. the headwaters and near Jack Creek) also have volcanic geology and have arsenic concentrations below the water quality target, the type of volcanics along Burnt Hollow Creek are different and may be the source of elevated arsenic. A study by the Watershed Restoration Coalition found arsenic and copper to be slightly elevated in the upland topsoil of several drainages in the east valley and attributed it to atmospheric deposition from the Anaconda Smelter (Keck and Kozar, 2003), but the water quality effects of smelter fallout in areas of lesser deposition is unknown. Based on the water quality sampling in 2002, the arsenic water quality target exceedance seems to be related to a source on Burnt Hollow Creek, whereas atmospheric deposition typically is diffuse and results in water quality target exceedances in numerous locations within an affected watershed. Additionally, smelter fallout usually results in high flow water quality target exceedances for other COCs, such as cadmium, copper, lead, or zinc, and none of those metals had water quality target exceedances at high flow. Therefore, because the arsenic water quality target exceedance cannot be clearly associated with an anthropogenic source and lower Peterson Creek is not currently listed for arsenic, no arsenic TMDL will be developed for the lower segment of Peterson Creek and additional sampling is recommended to help better characterize water quality and refine the source assessment.

During high flow sampling, the sample near the mouth exceeded the iron water quality target. As discussed in **Section 7.4.4.12** for the upper segment of Peterson Creek, a sample at the downstream end of the upper segment also exceeded the iron target, indicating the upper segment is a source of iron. Flow decreased by almost half from the upper segment to the mouth because of irrigation withdrawals, but the concentration increased by 28 percent. Additionally, over the same distance, the TSS concentration increased from 28mg/L to 41mg/L, suggesting the water quality target exceedance is associated with sediment. As discussed in **Section 5.0**, beneficial use support in the lower segment of Peterson Creek is being affected because of anthropogenic sources of sediment and requires sediment TMDL development. Based on the anthropogenic sources in the watershed and water quality target exceedance, an iron TMDL will be developed for the lower segment of Peterson Creek. Because there is very limited data for lower Peterson Creek, additional monitoring is recommended to help better characterize the water quality and refine the source assessment.

7.4.4.14 Warm Springs Creek, Lower Segment (MT76G002_012)

The lower segment of Warm Springs Creek was listed for arsenic, copper, and lead on the 2008 303(d) List. The segment flows 14.5 miles from Meyers Dam near Warm Springs to the mouth at the Clark Fork River (**Figure A-32**).

Sources and Available Data

There are numerous abandoned mines in the upper watershed that could be potential sources to the lower segment, however, the upper segment is not currently on the 303(d) List for metals. The abandoned mine databases indicate a few placer mines along the lower segment, but the predominant sources along the lower segment are the Old Works and Anaconda smelters and associated processing facilities and wastes. These sources, as well as the lower segment of Warm Springs Creek, are included within the Anaconda Superfund Site. The primary COCs for the Anaconda Superfund Site are arsenic, cadmium, copper, lead, and zinc. Within the ROD for the Site, identified sources include smelter stack emissions and the resulting poorly vegetated soils, wastes in the floodplain, fluvially deposited wastes which originally entered the creek near Anaconda, bed sediment from the Old Works/Stuckey Ridge area, and channelization and flow alterations that increased erosion of tailings in the streambanks (EPA and DEQ, 1998).

As shown in **Table 7-2**, remediation occurred in the late 1990s and early 2000s at the Arbiter Plant (i.e. copper refinery), heap roast slag piles, the Red Sands (i.e. the product of sluicing tailings and slag across the creek), the Anaconda Ponds, and the Opportunity Ponds (**Figure A-33**) (Lipton, 1993; U.S.EPA, 2005). Effectiveness monitoring, performance evaluations, and maintenance for the selected remedies are ongoing for the sites where remediation has occurred. One of the last phases of the Superfund cleanup involves addressing remaining contamination, including partial removal of streamside wastes and revegetating near streams. Soil investigations conducted as part of the RI have found additional tailings, but no single predominant source has been identified (CDM, 2009). Because of the extent of historical mining in the watershed, remaining sources are likely dispersed and include mining wastes in the floodplain, along the stream channel, and in the bed sediment. Additionally, the Opportunity Ponds have been identified as a source of ground water contamination to Warm Springs Creek (NRDP, 1999; Lipton, 1993). The North Drain Ditch, which is a dewatering ditch that collects ground water along the north side of the Opportunity Ponds, flows into Warm Springs Creek (**Figure A-32**).

Storm water from the town of Anaconda may be a source of metals, but it is not a permitted source because the population is not large enough for Anaconda to be considered a Municipal Separate Storm Sewer System. Anaconda is in the process of inventorying and sampling its storm sewer outfalls, but there is currently no available sampling data.

There are two permitted point sources that discharge to Warm Springs Creek: the Washoe Park Fish Hatchery and Anaconda Foundry Fabrication Company (AFFCO). The primary substances in the effluent from the fish hatchery are fish food and waste (i.e. unprocessed food, nutrients, and total suspended solids), which are regulated in its permit. The hatchery has no monitoring requirements for metals. Fish food and waste may contain trace concentrations of metals, but by regulating their concentrations within the effluent, the hatchery is not likely to be a source of metals to Warm Springs Creek. A well provides the source water for the hatchery, which has a flow-through system. The source water was analyzed by FWP in 2001 and 2002 and was below the detection limit for all metals (Skaar, 2002). All detection limits were less than the chronic aquatic life standards, but the arsenic detection limit (50µg/L) was greater than the human health standard (10µg/L). However, as discussed in the data summary below, arsenic water quality target exceedances in Warm Springs Creek are infrequent and associated with high flow, indicating that the hatchery's source water does not have elevated arsenic concentrations. Therefore, it is assumed that the Washoe Park Fish Hatchery is not a source of metals to Warm Springs Creek. AFFCO has an industrial storm water permit and submits biannual monitoring reports for its discharge. Since 2006, measurable discharge has occurred once at the facility in 2007. Although the facility has implemented numerous BMPs, including a vegetated ditch and settling basins, and does not typically produce discharge, the concentrations of arsenic, copper, lead, and zinc during the sampling event were greater than the benchmark values in the General

Industrial Storm Water permit and may contribute to elevated metals concentrations in Warm Springs Creek during storm events.

The metals listings for Warm Springs Creek are based on consistent target exceedances for arsenic, copper, and lead in the 1980s and 1990s, with copper being the most commonly exceeded target prior to Superfund remediation. As part of the RI and follow-up work to fill data gaps, samples have been collected from Warm Springs Creek and analyzed for the COCs at six primary locations (**Figure A-32**; WS-1 to WS-6) under various hydrologic conditions (**Table 7-31**). Data associated with the RI will be summarized within this section but raw data are contained within a series of Superfund-related reports (ARCO, 2002a; Pioneer Technical Services, Inc., 2002; Pioneer Technical Services, Inc., 2004; CDM, 2009). Other recent data has been collected by both USGS and DEQ. The USGS data consists of 62 water samples collected at the gage station near Anaconda (#12323760, n=16) and at the gage at Warm Springs (#12323770, n=46) since 2002 (**Figure A-32**). Between the two gages, there are two major diversions: Gardiner Ditch, which withdraws a substantial amount of water (typically between May and September) (EPA, 2005), and the FWP diversion near Warm Springs. Data from the gaging stations are summarized in **Table 7-32** for all listed metals and any other metals with target exceedances. Other recent data includes monthly water samples collected at the upper end of the segment by the Tri-State Water Quality Council for arsenic in 2005 (**Figure A-32**; site CFRPO-6) and sediment samples and high and low flow water samples collected by DEQ between 2006 and 2008 at three sites (**Figure A-32**, **Tables 7-33** and **7-34**). Additionally, as part of long term monitoring throughout the Upper Clark Fork watershed, a sediment sample was collected at the gage at Warm Springs in 2002 (**Table 7-34**) (Dodge et al., 2003). To help characterize the entire watershed, DEQ also collected samples at five sites in the upper segment of Warm Springs Creek (**Figure A-32**; WSA-01 to WSA-05). Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented in **Tables 7-33** and **7-34**.

Table 7-31. Hydrologic distribution of recent sample data collected on Warm Springs Creek as part of the Anaconda Smelter Superfund Site Remedial Investigation.

Event Type	Sample Dates
Low Flow	March 1999[1]
High Flow	June 1999[1], June 2008 (high and peak flow)
Storm-event	July 2001[1], July-September 2002

[1] **Table 7-2** lists 2002 – current as recent data but 1999 and 2001 are discussed here because the Surface Water Technical Memorandum (Pioneer Technical Services, Inc., 2002) refers to 1999 data as post-Remedial Action as a result of the substantial amount of reclamation that occurred between the early and late 1990s

Table 7-32. Summary of USGS gage data for Warm Springs Creek relative to water quality targets.

Bold denotes water quality target exceedances.

Metal	Gage	n	Human Health Exceedances	Chronic Exceedances	Acute Exceedances	Median (µg/L)	Concentration Range (µg/L)
Arsenic	Anaconda	16	0	0	0	2.4	2 – 3.2
	Warm Springs	46	5	0	0	6.0	3.7 — 22
Cadmium	Anaconda	16	0	0	0	0.03	0.02 – 0.07
	Warm Springs	46	0	3	0	0.06	0.03 – 0.41

Table 7-32. Summary of USGS gage data for Warm Springs Creek relative to water quality targets.

Bold denotes water quality target exceedances.

Metal	Gage	n	Human Health Exceedances	Chronic Exceedances	Acute Exceedances	Median (μg/L)	Concentration Range (μg/L)
Copper	Anaconda	16	0	0	0	2.4	1.2 – 4.7
	Warm Springs	46	0	**14**	**13**	7.7	4.5 — 108
Iron	Anaconda	16	N/A[1]	0	N/A	76	28 — 237
	Warm Springs	46	N/A[1]	3	N/A	92	54 — 1700
Lead	Anaconda	16	0	0	0	0.25	0.08 – 0.62
	Warm Springs	46	0	**5**	0	0.5	0.21 – 10.7
Zinc	Anaconda	16	0	0	0	2.0	1 – 5.5
	Warm Springs	46	0	0	0	3.0	1.2 — 39

[1] The human health standard is a Secondary Maximum Contaminant Level associated with aesthetic properties and only impairs the drinking water beneficial use if it cannot be removed via conventional treatment

Table 7-33. Metals data for lower Warm Springs Creek.

Bold denotes water quality target exceedances and "--" indicates no data.

Sample Site	Location	Sample Date	Flow (cfs)	Hardness (mg/L as $CaCO_3$)	Total Recoverable Metal in Water Column (μg/L)					
					As	Cd	Cu	Fe	Pb	Zn
C01WR MSC02	Stumptown Road crossing	9/29/2006	--	114	2	<.08	<1	30	<.5	1.4
WSA-06	upstream of Anaconda	8/30/2007	24.59	115	<3	<.08	<1	<50	<.5	<10
WSA-07	Downstream of Anaconda	8/30/2007	43.02	122	<3	<.08	2	90	<.5	<10
WSA-08	Near mouth	8/31/2007	37.79	153	5	<.08	5	80	<.5	<10
WSA-06	Upstream of Anaconda	5/29/2008	200	74	<3	<.08	2	120	<.5	<10
WSA-07	Downstream of Gardiner Ditch	5/30/2008	205	87	<3	<.08	2	20	<.5	<10
WSA-08	Near mouth	5/30/2008	156	101	4	<.08	**17**	260	1.6	<10

Table 7-34. Sediment metals concentrations (ug/g dry weight) for lower Warm Springs Creek.

Bold denotes supplemental indicator value exceedances and "--" indicates no data.

Sample Site	Location	Sample Date	As	Cd	Cu	Pb	Zn
12323770	USGS gage at Warm Springs	8/2002	--	**5.8**	**881**	67	**373**
WSA-06	Upstream of Anaconda	8/30/2007	**27.3**	1.29	154	33	259
WSA-07	Downstream of Gardiner Ditch	8/30/2007	16	0.82	**244**	59.7	313
WSA-08	Near mouth	8/31/2007	**85.2**	2.48	**1020**	83.8	**367**

Comparison to Water Quality Targets and TMDL Development Determination

Arsenic

Five samples at the gage at Warm Springs exceeded the arsenic water quality target. All but one of the exceedances occurred during high flow. None of the DEQ or Tri-State Water Quality Council samples exceeded the water quality target, but one of the high flow samples was at the target (10μg/L). At the Superfund sites, none of the low flow samples exceeded the water quality target but two high flow samples at WS-5 and one at WS-6 exceeded the water quality target. Additionally, during storm events, the arsenic water quality target was exceeded three times at WS-3 and once at WS-1 and WS-5. Sediment concentrations upstream of Anaconda (WSA-06) and near the mouth (WSA-08) exceeded the supplemental indicator value for arsenic, but the concentration at WSA-06 was similar to concentrations at the sites in the upper segment, whereas the concentration at WSA-08 was five times greater than the PEL. Based on the target and supplemental indicator exceedances, an arsenic TMDL will be developed for the lower segment of Warm Springs Creek.

Copper

Fourteen samples at the gage at Warm Springs exceeded the copper water quality target. One DEQ sample exceeded the water quality target during high flow near the mouth (WSA-08). At the Superfund sites, the water quality target was exceeded during all high flow events at sites downstream of Anaconda (i.e. WS-3 or WS-4 to the mouth at WS-6). The water quality target was exceeded during at least one storm event at all sites; the most frequent target exceedances during storm events occurred at WS-3 and WS-5. The elevated DEQ sample and most of the exceedances at the gage and Superfund sites were greater than the acute aquatic life standard. Three of the sediment samples exceeded the supplemental indicator value for sediment, and both sites near the mouth (at the Warm Springs gage and WSA-08) were four to five times greater than the PEL. Two of the sediment samples from the upper segment of Warm Springs Creek were greater than the supplemental indicator value for copper, indicating sediment from the upper part of the watershed may be contributing to target exceedances in the lower segment during periods of high flow when the residence time upstream of Myers Dam is shortened. Based on the target and supplemental indicator exceedances, a copper TMDL will be developed for the lower segment of Warm Springs Creek.

Because of the sediment exceedances in the upper segment, historical Superfund data from WS-1 and recent DEQ samples from the upper segment were reviewed. There were no target exceedances for copper, suggesting sediment in the upper sediment is unlikely to be contributing to target exceedances in the upper or lower segment. However, elevated sediment concentrations could be affecting benthic organisms in the upper segment. Although there is no macroinvertebrate data for the upper segment segment, and monitoring is recommended, the TMDL for the lower segment incorporates all sources in the watershed and will address sources in the upper watershed.

Lead

Five samples at the gage at Warm Springs exceeded the water quality target for lead. None of the DEQ samples exceeded the water quality target. At the Superfund sites, high flow samples from WS-4 to WS-6 exceeded the water quality target and there were numerous target exceedances at WS-3 and WS-5 during storm event sampling. Generally during storm events, lead concentrations decreased downstream of WS-3. None of the sediment samples exceeded the supplemental indicator value for lead. Based on the target exceedances, a lead TMDL will be developed for the lower segment of Warm Springs Creek.

Cadmium, Iron, and Zinc
Although Warm Springs Creek is not listed for cadmium, iron, or zinc, each metal had target exceedances at the gage at Warm Springs and/or Superfund sites. At the gage, there were three target exceedances during high flow for both cadmium and iron. At the Superfund sites, high and low flow samples at WS-5, a high flow sample at WS-6, and multiple storm event samples at WS-3 and WS-5 exceeded the cadmium water quality target. Two storm event samples at WS-3 and one high flow sample at WS-4A exceeded the zinc water quality target. There was blank contamination in the high flow sampling run for cadmium at WS-5 and zinc at WS-4A, but based on numerous other water quality target exceedances for both cadmium and zinc, the elevated concentrations are likely valid. Of the sediment samples, the sample at the Warm Springs gage exceeded the supplemental indicator value for cadmium and samples from both the gage and near the mouth (WSA-08) exceeded the supplemental indicator value for zinc. Based on the target and supplemental indicator value exceedances, TMDLs will be developed for cadmium, iron, and zinc for the lower segment of Warm Springs Creek.

7.4.4.15 Willow Creek, Upper Segment (MT76G002_061)

The upper segment of Willow Creek (**Figure A-34**) was listed for arsenic, cadmium, copper, and lead on the 2008 303(d) List. The upper segment of Willow Creek flows 5.5 miles from the headwaters to Section 30, Township 4N, Range 10W.

Sources and Available Data
The abandoned mine databases do not indicate any abandoned mines within the upper Willow Creek watershed. However, all of Willow Creek is within the Anaconda Smelter Superfund Site. Much of the upper segment flows through Mount Haggin, which has been identified as an upland area with elevated metals concentrations in the soil and ground water because of atmospheric deposition from the Anaconda Smelter (Environmental Science and Engineering, Inc., 1995; EPA and DEQ, 1998).

The metals listings were based on sampling within the upper segment and upstream end of the lower segment in the mid-1990s that was associated with the Superfund RI and also DEQ samples collected in 2004. As part of the RI and follow-up work to fill data gaps, samples have been collected from the upper segment of Willow Creek and analyzed for the COCs at five locations (**Figure A-34** and **Table 7-36**; WC-4 to WC-8) during high and low flow in 2001. Sampling was also conducted on tributaries near the mainstem sites. Storm event sampling was conducted within the lower segment in 2002 and one of the sites, WC-13, was located about one mile downstream of the upper segment (**Figure A-34**) and likely represents metals concentrations in the upper segment during storm events. Some of the data associated with the RI is presented within this section but the remaining data are summarized and raw data are contained within a series of Superfund-related reports (ARCO, 2001; ARCO, 2002c; CDM, 2007). Other recent data has been collected on the upper segment of Willow Creek by both USGS and DEQ. The USGS data consists of 29 samples collected at the gage station near Anaconda since 2004 (#12323710, **Figure A-34**). Data from the gage station is summarized in **Table 7-35** for all listed metals and any other metals with target exceedances. The DEQ data includes sediment samples and high and low flow water samples collected by DEQ in 2007/2008 at four sites (**Figure A-34**, **Tables 7-36** and **7-37**). Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented in **Tables 7-36** and **7-37**.

Table 7-35. Summary of USGS gage data for upper Willow Creek relative to water quality targets.

Bold denotes water quality target exceedances.

Metal	Gage	n	Human Health Exceedances	Chronic Exceedances	Acute Exceedances	Median (µg/L)	Concentration Range (µg/L)
Arsenic	Anaconda	29	**27**	0	0	15.3	9.8 - 27
Cadmium	Anaconda	29	0	**1**	0	0.05	0.02 – 0.19
Copper	Anaconda	29	0	**10**	**7**	3.7	1 – 16.8
Iron	Anaconda	29	N/A[1]	**1**	N/A	206	93 - 1260
Lead	Anaconda	29	0	**11**	0	0.47	0.1 – 4.08
Zinc	Anaconda	29	0	0	0	1.7	1 - 10

[1] The human health standard is a Secondary Maximum Contaminant Level associated with aesthetic properties and only impairs the drinking water beneficial use if it cannot be removed via conventional treatment

Table 7-36. Metals data for upper Willow Creek.

Bold denotes water quality target exceedances and "–" indicates no data.

Sample Site	Location	Sample Date	Flow (cfs)	Hardness (mg/L as $CaCO_3$)	Total Recoverable Metal in Water Column (µg/L)					
					As	Cd	Cu	Fe	Pb	Zn
WC-4	Downstream of Twin Lakes Creek	4/26/2001	2.65	33	4.3[1]	0.031[1]	<8	356	**2.6[1]**	<4.1
WC-5	Downstream of Elk Creek	4/26/2001	5.12	29	**11.1**	0.051[1]	<8	367	**3.8**	<4.1
WC-6	Downstream of Long Canyon Creek	4/26/2001	6.29	32	**18.5**	0.057[1]	<8	587	**3.3**	<4.1
WC-7	Upstream of gage at Anaconda	4/26/2001	7.42	34	**16.7**	0.092[1]	<8	601	**4.6**	<4.1
WC-8	Downstream end of segment	4/26/2001	7.54	42	**17.1**	0.079[1]	8.9	532	**2.8[1]**	<4.1
WC-4	Downstream of Twin Lakes Creek	8/28/2001	0.52	41.2	3.9[1]	0.063[1]	<1.6	47.2[1]	**3.8**	<7.6
WC-5	Downstream of Elk Creek	8/28/2001	1.14	37.1	**11.3**	0.11[1]	3.3[1]	98.4[1]	**4.7**	**<74.9**
WC-6	Downstream of Long Canyon Creek	8/28/2001	1.4	37.3	**13.8**	0.13[1]	2.0[1]	54.6[1]	**4.1**	<38.7
WC-7	Upstream of gage at Anaconda	8/28/2001	1.05	42.1	**29.4**	0.10[1]	<3.8	464	**4.9**	<39.6
WC-8	Downstream end of segment	8/28/2001	0.88	49	**54.5**	0.049[1]	4.1	543	**3.5[1]**	<22.9

Table 7-36. Metals data for upper Willow Creek.
Bold denotes water quality target exceedances and "–" indicates no data.

Sample Site	Location	Sample Date	Flow (cfs)	Hardness (mg/L as $CaCO_3$)	Total Recoverable Metal in Water Column (µg/L)					
					As	Cd	Cu	Fe	Pb	Zn
C01WILWC01	Downstream of Long Canyon Creek	7/14/2004	2.21	33	**12**	<.1	1	50	<.5	<10
WLW-01	Tributary to headwaters	8/28/2007	0.53	39.8	4	<.08	<1	<50	<.5	<10
WLW-02	At headwaters	8/28/2007	4.21	36.7	10	<.08	1	60	<.5	<10
WLW-03	Elk Creek Tributary	8/28/2007	0.97	32	**32**	0.09	**4**	280	**0.8**	<10
WLW-04	Long Canyon Creek Tributary	8/28/2007	0.5	59.1	**12**	<.08	2	130	<.5	10
WLW-05	Downstream of Anaconda gage at bottom of segment	8/29/2007	1.27	40.2	**14**	<.08	2	90	<.5	10
WLW-01	Tributary to headwaters	5/27/2008	21.1	29	6	<.08	**4**	450	1	<10
WLW-02	At headwaters	5/27/2008	24.4	20	**26**	**0.5**	**20**	**3350**	**12.6**	30
WLW-03	Elk Creek Tributary	5/27/2008	10.0	20	**53**	<.08	**10**	**1460**	**4.5**	10
WLW-04	Long Canyon Creek Tributary	5/27/2008	6.99	44	**19**	0.11	**8**	760	**2.4**	<10
WLW-05	Downstream of Anaconda gage at bottom of segment	5/27/2008	98	31	**24**	<.08	**14**	**2050**	**7.3**	20

[1] Value is greater than the instrument detection limit but less than the contract required detection limit

Table 7-37. Sediment metals concentrations (ug/g dry weight) for upper Willow Creek.
Bold denotes supplemental indicator value exceedances.

Sample Site	Location	Sample Date	As	Cd	Cu	Pb	Zn
WLW-01	Tributary to headwaters	8/28/2007	**21**	1.3	146	46.2	119
WLW-02	At headwaters	8/28/2007	**35.5**	1.91	168	63.5	153
WLW-03	Elk Creek tributary	8/28/2007	**50.4**	3.29	**262**	55.6	203
WLW-04	Long Canyon Creek tributary	8/28/2007	**35.1**	2.56	**304**	73.6	217
WLW-05	Downstream of Anaconda gage at bottom of segment	8/29/2007	**57.1**	2.53	**286**	67.5	192

Comparison to Water Quality Targets and TMDL Development Determination

Arsenic

Almost all of the 29 samples at the gage near Anaconda exceeded the arsenic water quality target. Concentrations at the gage were generally greatest during low flow. At the Superfund sites, the target was exceeded during high and low flow sampling at all sites except the uppermost site (WC-4). During high flow, concentrations increased slightly in a downstream direction, but during low flow, the concentration increased substantially at both WC-7 and WC-8. The arsenic water quality target was exceeded at WC-13 during all five storm events. During DEQ sampling, target exceedances occurred during both high and low flow. Target exceedances also occurred on tributary sites during Superfund-related sampling in 2001 and DEQ sampling in 2007/2008; the maximum arsenic concentration consistently occurred at Elk Creek. All sediment samples exceeded the supplemental indicator value for arsenic. The concentration was the lowest at the tributary to the headwaters (WLW-01) and just greater than the PEL but was two to three times greater than the PEL at all other sites. Based on the target and supplemental indicator value exceedances, an arsenic TMDL will be developed for the upper segment of Willow Creek.

Cadmium

One sample at the gage station during high flow exceeded the cadmium water quality target. Among high and low flow samples at Superfund and DEQ sites, only one other sample exceeded the water quality target, and it was near the headwaters (WLW-02) during high flow. The water quality target was exceeded at WC-13 during all five storm events, indicating cadmium target exceedances are primarily an issue during high flow and storm events. None of the sediment samples exceeded the supplemental indicator value for cadmium. Based on the target exceedances, a cadmium TMDL will be developed for the upper segment of Willow Creek.

Copper

Ten samples at the gage station exceeded the copper water quality target. Most of the exceedances occurred during high flow but the greatest concentration occurred during low flow. At the Superfund sites, one sample at the lower end of the segment (WC-8) exceeded the water quality target during high flow, but the concentrations at the other sites cannot be evaluated because the detection limit was greater than the target. The copper water quality target was exceeded at WC-13 during all five storm events. None of the Superfund sites exceeded the target during low flow. At the DEQ sites, the Elk Creek tributary site (WLW-03) was the only target exceedance during low flow, but all sites exceeded the copper target during high flow and the concentration was the greatest near the headwaters (WLW-02). Most of the target exceedances at all site types were greater than the acute water quality standard for copper. For sediment, two of the tributary samples (WLW-03 and WLW-04) and the site at the lower end of the segment (WLW-05) exceeded the supplemental indicator value for copper. Based on the target and supplemental indicator value exceedances, a copper TMDL will be developed for the upper segment of Willow Creek.

Lead

Eleven samples at the gage station exceeded the lead water quality target. Most of the exceedances occurred during high flow. At the Superfund sites, the water quality target was exceeded during high and low flow at all sites. Additionally, the lead water quality target was exceeded at WC-13 during all five storm events. At the DEQ sites, the Elk Creek tributary site (WLW-03) was the only target exceedance during low flow, but all sites exceeded the lead target during high flow and the concentration was the greatest near the headwaters (WLW-02). None of the sediment samples exceeded the supplemental indicator value for lead. Based on the target exceedances, a lead TMDL will be developed for the upper segment of Willow Creek.

Iron and Zinc

Although the upper segment of Willow Creek is not listed for iron or zinc, there were water quality target exceedances for both metals. For iron, one high flow sample at the gage station and two high flow samples at the DEQ sites (WLW-02 and tributary site WLW-03) exceeded the water quality target. For zinc, a storm event sample at WC-13 exceeded the water quality target; the concentration was greater than the acute aquatic life standard. Additionally, during low flow sampling at the Superfund sites, the detection limit was variable because of quality control issues, but the detection limit at one of the sites (WC-5) was almost double that at the other sites and greater than the zinc water quality target, indicating the sample may have exceeded the water quality target. None of the sediment samples exceeded the zinc supplemental indicator value. Although the dataset is limited and additional sampling is recommended, because the exceedances are occurring in an area known to have elevated erosion associated with historic atmospheric deposition associated with the Anaconda Smelter, iron and zinc TMDLs will be developed for the upper segment of Willow Creek.

7.4.4.16 Willow Creek, Lower Segment (MT76G002_062)

The lower segment of Willow Creek (**Figure A-34**) was listed for arsenic, cadmium, copper, and lead on the 2008 303(d) List. The lower segment of Willow Creek flows 7.4 miles from Section 30, Township 4N, Range 10W to the mouth at the Mill-Willow Bypass.

Sources and Available Data

The abandoned mine databases do not indicate any abandoned mines along the lower segment of Willow Creek. However, all of Willow Creek is within the Anaconda Smelter Superfund Site. Historically, the upper segment was partially dewatered by the Yellow Ditch (**Figure A-34**) but the lower segment flowed to the mouth because of ground water recharge within the channel. The Yellow Ditch was used in the 1930s to flood the Opportunity Ponds with water from Silver Bow Creek (Pioneer Technical Services, Inc., 2002). Yellow Ditch was likely a historical source of metals to Willow Creek because it transported water (and tailings) from Silver Bow Creek and its path cut through the Willow Creek watershed, and as recently as 1995 return flow during high flow was cited as a potential metals source (Environmental Science and Engineering, Inc., 1995). However, due to changes in irrigation management, Yellow Ditch is not likely to be a metals source because it is not hydrologically connected to Willow Creek and is used only to transfer irrigation water from Mill Creek to irrigation fields south of Opportunity. Currently, there are inputs from approximately 11 tile drains that intercept ground water near Opportunity and also several irrigation ditches and returns along the lower segment that may transfer metals within the watershed or even between watersheds. Based on Superfund-related sampling, four of the tile drains have elevated arsenic and copper concentrations and five of the tile drains have very low metals concentrations (personal comm. C. Coover, 2009). The railroad line that comes from the south and crosses Willow Creek near the top of the segment is another potential source (**Figure A-34**); the railroad crossing has fill composed of tailings, and up the rail line, along South Fork Willow Creek, there are ponds associated with the railroad (i.e. Blue Lagoon and Son of Blue Lagoon) that have elevated heavy metals. Other potential metals sources for the lower segment include fluvially deposited tailings from Silver Bow Creek that were historically deposited in the shared floodplain between the two creeks (i.e. generally north of Hwy 1), runoff from areas of historic atmospheric deposition from the Anaconda Smelter, and metals-rich ground water associated with either tailings or atmospheric deposition (Environmental Science and Engineering, Inc., 1995; EPA and DEQ, 1998). All of these sources have been identified during the Superfund RI and will be addressed to differing levels as remediation at the Anaconda Smelter Superfund Site continues.

The metals listings were based on sampling within the lower segment in the mid-1990s that was associated with the Superfund Remedial Investigation and also DEQ samples collected in 2004. As part of the RI and follow-up work to fill data gaps, samples have been collected from the lower segment of Willow Creek and analyzed for the COCs at four primary locations (**Figure A-34**; WC-12 to WC-15) under various hydrologic conditions (**Table 7-38**). Several tributaries were also sampled; most of the tributary sampling occurred on South Fork Willow Creek and Willow Glen Creek (**Figure A-34**). Data associated with the RI, including short-term tributary, irrigation, and tile drain sites, will be summarized within this section but raw data are contained within a series of Superfund-related reports (ARCO, 2001; ARCO, 2002c; ARCO, 2002b; Pioneer Technical Services, Inc., 2002; Pioneer Technical Services, Inc., 2004; CDM, 2007). Other recent data has been collected by both USGS and DEQ. The USGS data consists of samples collected at the gage station at Opportunity since 2003 (#12323720, **Figure A-34**). Data from the gage station is summarized in **Table 7-39** for all listed metals and any other metals with target exceedances. USGS conducted diel (i.e. 24 hour) sampling at the gage station in March and June 2008 to assess daily variability in metals concentrations; so that values from those sampling events are not over-represented within the data summary, only the maximum measured concentration for each metal per diel sampling event was evaluated for **Table 7-39**. The DEQ data includes sediment samples and high and low flow water samples collected by DEQ in 2007/2008 at four sites (**Figure A-34**, **Tables 7-40** and **7-41**). Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented in **Tables 7-40** and **7-41**.

Table 7-38. Hydrologic distribution of recent sample data collected on lower Willow Creek as part of the Anaconda Smelter Superfund Site Remedial Investigation.

Event Type	**Sample Dates**
Low Flow	March 1999, August 2001, April 2007
High Flow	April 2001, June 2007
Storm-event	July-September 2002

Table 7-39. Summary of USGS gage data for lower Willow Creek relative to water quality targets.

Bold denotes water quality target exceedances.

Metal	Gage	n	Human Health Exceedances	Chronic Exceedances	Acute Exceedances	Median (µg/L)	Concentration Range (µg/L)
Arsenic	Opportunity	49	**49**	**1**	0	31.6	12 – 164
Cadmium	Opportunity	49	0	**2**	0	0.07	0.02 – 0.52
Copper	Opportunity	49	0	**17**	**12**	8.2	2.8 – 48.8
Iron	Opportunity	49	N/A[1]	**1**	N/A	204	27 – 1420
Lead	Opportunity	49	0	**10**	0	1.6	0.27 – 14.4
Zinc	Opportunity	49	0	0	0	10.0	1.1 – 68

[1] The human health standard is a Secondary Maximum Contaminant Level associated with aesthetic properties and only impairs the drinking water beneficial use if it cannot be removed via conventional treatment

Table 7-40. Metals data for lower Willow Creek.

Bold denotes water quality target exceedances and "--" indicates no data.

Sample Site	Location	Sample Date	Flow (cfs)	Hardness (mg/L as $CaCO_3$)	Total Recoverable Metal in Water Column (µg/L)					
					As	Cd	Cu	Fe	Pb	Zn
C01WI LWC02	Near the railroad crossing	7/14/2004	1.95	43	**44**	<.1	**6**	290	0.9	<10
WLW-08	Upstream of Yellow Ditch	8/29/2007	1.19	45	**33**	0.08	4	510	**1.2**	10
WLW-09	Downstream of Yellow Ditch	8/29/2007	0.84	45	**35**	0.1	**5**	540	**1.5**	20
WLW-11	Near mouth	9/13/2007	5.85	142	**13**	<.08	3	60	1.4	<10
WLW-06	Unnamed trib at upstream end of segment	5/28/2008	0.24	135	**42**	<.08	5	80	<.5	<10
WLW-08	Upstream of Yellow Ditch	5/28/2008	75	29	**23**	<.08	**11**	**1170**	**3.4**	10
WLW-09	Downstream of Yellow Ditch	5/28/2008	26.29	31	**25**	<.08	**11**	**1140**	**3.1**	10
WLW-11	Near mouth	5/28/2008	74.21	83	**77**	**0.26**	**31**	890	**8**	40

Table 7-41. Sediment metals concentrations (ug/g dry weight) for lower Willow Creek.

Bold denotes supplemental indicator value exceedances.

Sample Site	Location	Sample Date	As	Cd	Cu	Pb	Zn
WLW-08	Upstream of Yellow Ditch	8/29/2007	**69.4**	2.36	**242**	68.9	231
WLW-09	Downstream of Yellow Ditch	8/29/2007	**67.1**	2.9	**212**	75.7	222
WLW-11	Near mouth	9/13/2007	**110**	**4.92**	**507**	**249**	**881**

Comparison to Water Quality Targets and TMDL Development Determination

Arsenic

All samples at the gage station at Opportunity and at the DEQ sites exceeded the arsenic water quality target. At the gage, concentrations were greatest during high flow. At the DEQ sites, concentrations were greatest near the mouth during high flow, but during low flow, when ground water inputs are more apparent, concentrations were greater in the vicinity of the Yellow Ditch and decreased near the mouth. At the Superfund sites, samples were greater than the water quality target at all sites during all low flow and high flow sampling events. Overall, concentrations were greatest in the upper part of the segment at sites WC-13 and WC-12. Between those sites, much higher concentrations than in Willow Creek were measured during high and low flow in South Fork Willow Creek and a tile drain and irrigation return that drains irrigated lands in the Willow Glen watershed (**Figure A-34**). During storm event sampling, there were target exceedances at all sites during all storm events and concentrations were greatest near WC-13. All sediment concentrations were greater than the supplemental indicator value for arsenic; sites near the Yellow Ditch were four times greater than the PEL and the sample at the mouth was six times greater than the PEL. Based on the target and supplemental indicator value exceedances, an arsenic TMDL will be developed for the lower segment of Willow Creek.

Cadmium

Two of the samples at the gage at Opportunity exceeded the cadmium water quality target, and both exceedances occurred during high flow. At the DEQ sites, a high flow sample near the mouth (WLW-11) exceeded the water quality target. At the Superfund sites, the only low flow target exceedance occurred on South Fork Willow Creek. During high flow, target exceedances occurred near the upper end of the segment (WC-13) and just downstream of WC-13 in an irrigation return from Mill Creek in 2001 (which has been observed as blocked since 2007) (personal comm. C. Coover, 2009) and on South Fork Willow Creek in 2007. During storm event sampling, target exceedances occurred at WC-13 and in Willow Glen Creek. The sediment sample near the mouth (WLW-11) exceeded the supplemental indicator value for cadmium. Based on the target and supplemental indicator value exceedances, a cadmium TMDL will be developed for the lower segment of Willow Creek.

Copper

Twenty one of the samples at the gage at Opportunity exceeded the copper water quality target, and most of the exceedances were greater than the acute water quality standard. Target exceedances at the gage generally coincided with high flow but some exceedances also occurred during low flow. At the DEQ sites, water quality target exceedances occurred at two sites during low and at three sites during high flow. Concentrations were similar to arsenic in that during low flow, the sample downstream of Yellow Ditch had the greatest concentration, but during high flow, the sample near the mouth had the greatest concentration. At the Superfund sites, target exceedances occurred during low flow near the upper end of the segment (WC-13) in 2001 and in South Fork Willow Creek in 2008. During high flow and storm events, target exceedances occurred at all of the Superfund sites on Willow Creek. Storm event target exceedances also occurred in Willow Glen Creek, and high flow target exceedances also occurred in the irrigation return ditch from Mill Creek and a tile drain near Opportunity in 2001 and South Fork Willow Creek and an irrigation return near the railroad crossing in 2007. All of the sediment samples exceeded the supplemental indicator value for copper, and the sample near the mouth was the greatest at 2.5 times the PEL. Based on the target and supplemental indicator value exceedances, a copper TMDL will be developed for the lower segment of Willow Creek.

Lead

Eleven of the samples at the gage at Opportunity exceeded the lead water quality target, and all but one of the exceedances occurred during high flow. At the DEQ sites, water quality target exceedances occurred at two sites near Yellow Ditch during low flow and at the three sites from upstream of Yellow Ditch to the mouth during high flow. At the Superfund sites, one low flow target exceedance occurred in the upper part of the segment at WC-13. During high flow, exceedances occurred at three Superfund sites in 2001 and at WC-13 and South Fork Willow Creek in 2007. During storm events, target exceedances occurred at WC-13 and Willow Glen Creek during all events and near the mouth during one event. The sediment sample at the mouth was the only sample that exceeded the supplemental indicator value and was almost three times the PEL. Based on the target and supplemental indicator value exceedances, a lead TMDL will be developed for the lower segment of Willow Creek.

Iron and Zinc

Although the lower segment of Willow Creek is not listed for iron or zinc, water quality target exceedances occurred for both metals. One sample at the gage and two samples at the DEQ sites near Yellow Ditch exceeded the iron water quality target during high flow. During storm event sampling, zinc water quality target exceedances occurred during one event in the upper part of the segment at WC-13 and during two events in Willow Glen Creek. Additionally, the sediment sample near the mouth exceeded the supplemental indicator value for zinc and was almost three times the PEL. Based on the target and supplemental indicator value exceedances, TMDLs will be developed for iron and zinc.

7.4.5 TMDL Development Determination Summary

Sixteen stream segments in the Upper Clark Fork TPA require the development of 64 TMDLs for metals (**Table 7-42**). The metals of concern include arsenic, cadmium, copper, cyanide, iron, lead, selenium, and zinc. As discussed in **Section 4.4.4** by individual water body segment, some 303(d) listings either do not have adequate data for TMDL development at this time or a data review indicated TMDL development is not necessary. Additionally, as shown in **Table 7-42**, some metals were not listed on the 2008 303(d) List but based on a review of recent data, it was determined that a TMDL is necessary.

Table 7-42. Streams Requiring a TMDL for Metal Pollutants.

Water Body Segment ID	Water Body Segment	2008 303(d) Listings (metals-related)	Verified Target Exceedances and TMDL Developed
MT76G003_031	Beefstraight Creek	CN	CN
MT76G005_071	Dunkleberg Creek (upper)	Cd, Pb, Zn	As, Cd, Cu, Fe, Pb, Zn
MT76G005_072	Dunkleberg Creek (lower)	Pb	As, Cd, Cu, Fe, Pb, Zn
MT76G003_030	German Gulch	Se	As, CN, Se
MT76G005_091	Gold Creek (upper)	Pb	Pb
MT76G005_092	Gold Creek (lower)	Not listed	Fe, Pb

Table 7-42. Streams Requiring a TMDL for Metal Pollutants.

Water Body Segment ID	Water Body Segment	2008 303(d) Listings (metals-related)	Verified Target Exceedances and TMDL Developed
MT76G002_072	Lost Creek (lower)	As, Fe, Mn, SO4	As, Cu, Pb
MT76G002_051	Mill Creek (upper)	As, Cd, Cr, Cu, Pb, Zn	As, Cd, Cu, Pb, Zn
MT76G002_052	Mill Creek (lower)	Al, As, Cd, Cu, Fe, Pb, Zn	As, Cd, Cu, Fe, Pb, Zn
MT76G002_120	Mill-Willow Bypass	As, Cu, Pb	As, Cd, Cu, Pb, Zn
MT76G002_080	Modesty Creek	As	As, Cd, Cu, Pb
MT76G002_131	Peterson Creek (upper)	Cu	Cu, Fe, Pb
MT76G002_132	Peterson Creek (lower)	Not listed	Fe
MT76G002_012	Warm Springs Creek (lower)	As, Cu, Pb	As, Cd, Cu, Fe, Pb, Zn
MT76G002_061	Willow Creek (upper)	As, Cd, Cu, Pb	As, Cd, Cu, Fe, Pb, Zn
MT76G002_062	Willow Creek (lower)	As, Cd, Cu, Pb	As, Cd, Cu, Fe, Pb, Zn

7.5 TMDLs

TMDLs for metals represent the maximum amount of each metal that a stream can assimilate without exceeding water quality targets. A stream’s ability to assimilate metal pollutants is based on its ability to dilute metal concentrations (i.e., stream discharge), and for many metals, the water hardness (which can effect toxicity and determines the numeric water quality standard). Because both of these variables (stream flow and hardness) vary seasonally, the TMDL for a metal must be established so that it maintains protection of beneficial uses for the anticipated range of flow and hardness conditions.

Metals TMDLs are calculated using *Equation 1* (below). Note that the more stringent chronic aquatic life standards are used to calculate the TMDL. Using the chronic standard to calculate an allowable daily load, rather than a 96-hour load limit (see **Section 7.4.1.1**), affords an implicit margin of safety in calculating the TMDL and also establishes a daily load limit expression. For arsenic, the human health criterion is used in calculating the TMDL as it is more stringent than the chronic aquatic life standard.

Equation 1: TMDL = (X)*(Y)*(0.0054)

TMDL = Total Maximum Daily Load in lbs/day for metal of concern
X = the water quality target (µg/L) (typically based on the chronic aquatic life use standard)
Y = streamflow in cubic feet per second (cfs)
0.0054 = conversion factor

Metals sources contributing to chronic standard exceedances are typically the same metals sources that contribute to acute standard exceedances. In some instances, a spike in concentration during a storm event may result in non-attainment of the acute standard but attainment of the chronic standard (because chronic standards are based on a 96-hour average). Although the TMDL is derived from the chronic standards, acute aquatic life are also established as water quality targets, and are applied as an instantaneous in-stream pollutant concentration that shall not be exceeded (see **Section 7.4.1.1**). Remediation will be needed to address the sources of metals loading that contribute to the exceedance of water quality targets and to meet the allocations defined in **Section 7.6**. Most source reduction and remediation activities necessary to eliminate pollutant loading that exceeds the chronic standards will also mitigate shorter duration pulses that could contribute to an acute standards exceedance, but additional reductions may be necessary from storm-event related sources of metals loading that result in non-attainment of acute standards only.

Figures 7-4 through **7-7** show the TMDL for arsenic, cyanide, iron, and selenium under various flow conditions using *Equation 1* (above). The TMDL curves are applicable to all arsenic, cyanide, iron, and selenium TMDLs within this document. Example TMDLs, which were calculated using *Equation 1*, are shown in **Tables 7-43** and **7-44** for the 16 water body segments in the Upper Clark Fork TPA requiring one or more metals TMDLs. **Table 7-43** contains high and low flow TMDL examples for streams with limited effects from atmospheric deposition associated with the Anaconda Smelter, and **Table 7-44** contains high flow, low flow, and storm-event TMDL examples for streams affected by atmospheric deposition that tend to have storm-event water quality target exeedances. The calculated TMDLs represent the maximum load (lbs/day) of each metal that each water body can receive without exceeding applicable water quality standards for the specified streamflow conditions and water hardness.

TMDLs were calculated based on high and low flow sampling events (and storm events for some streams); DEQ sample data for the metals of concern are included in **Appendix D**. Superfund-related data is contained in a series of reports (ARCO, 2001; ARCO, 2002c; ARCO, 2002b; Pioneer Technical Services, Inc., 2002; Pioneer Technical Services, Inc., 2004; CDM, 2007; CDM, 2009). In general, there were at least two high flow sampling events and one low flow sampling event for each site, and all 303(d) listed water body segments have two or more sites. High flow samples are assumed to be between April 15th and June 30th and low flow samples are all other samples (unless collected for targeted storm-event sampling). The TMDL examples for each water body segment were generally calculated using sample data from sites with the greatest exceedance of the applicable water quality target. It is assumed that by addressing the sources needed to meet the TMDL at the location with the greatest exceedance will result in attainment of water quality standards throughout the water body. However, in cases where sampling data indicated additional downstream sources that may contribute to target exceedances, the downstream site was used for the TMDL example so that allocations to that water body segment using the example TMDL will address all significant sources. For each TMDL example, sample data were also used to calculate an existing load and determine the required percent load reduction to achieve the TMDL for each metal. Some TMDLs require a reduction at both high and low flow, whereas others only require a reduction during either high or low flow. For TMDLs with no reductions indicated, it is assumed based on elevated sediment metals concentrations that there are water column impairments not captured in the sample data set. Restoration activities to address metals sources and meet the TMDLs are expected to also address sediment-related toxicity and metals-related impairment to beneficial uses.

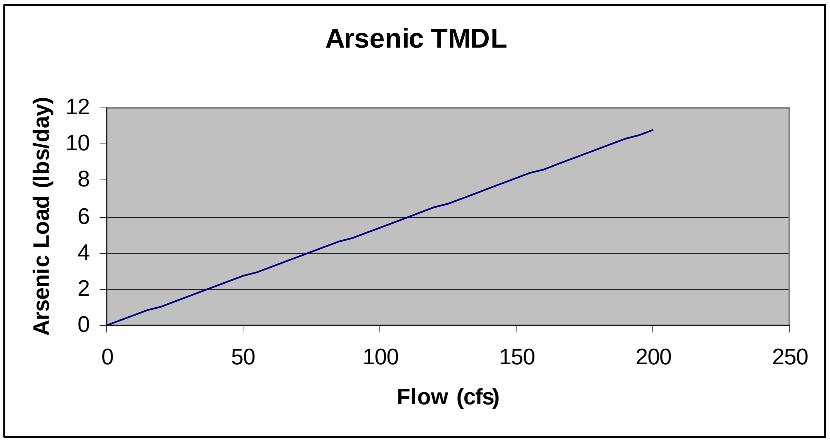


Figure 7-4. Arsenic TMDL curve that illustrates how the TMDL changes with flow.

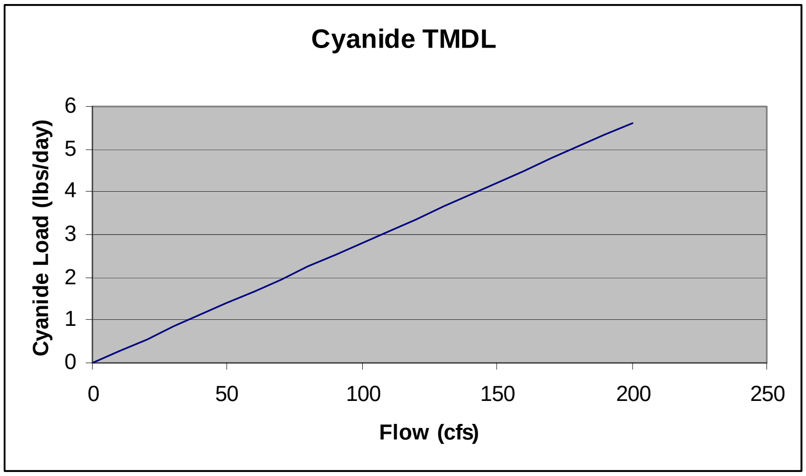


Figure 7-5. Cyanide TMDL curve that illustrates how the TMDL changes with flow.

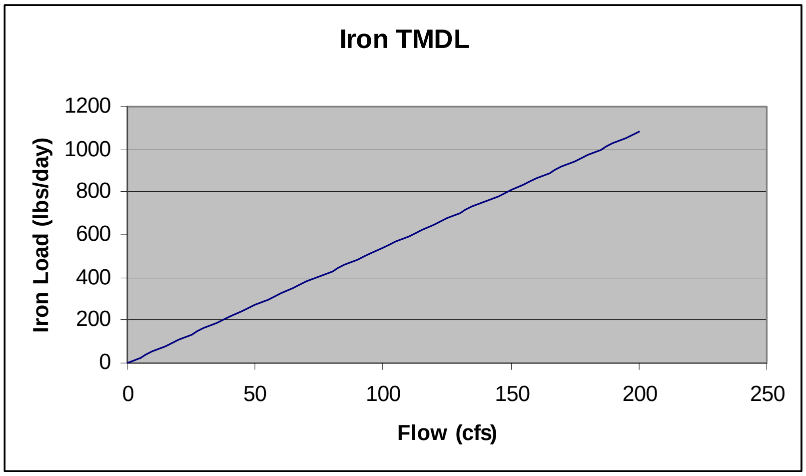


Figure 7-6. Iron TMDL curve that illustrates how the TMDL changes with flow.

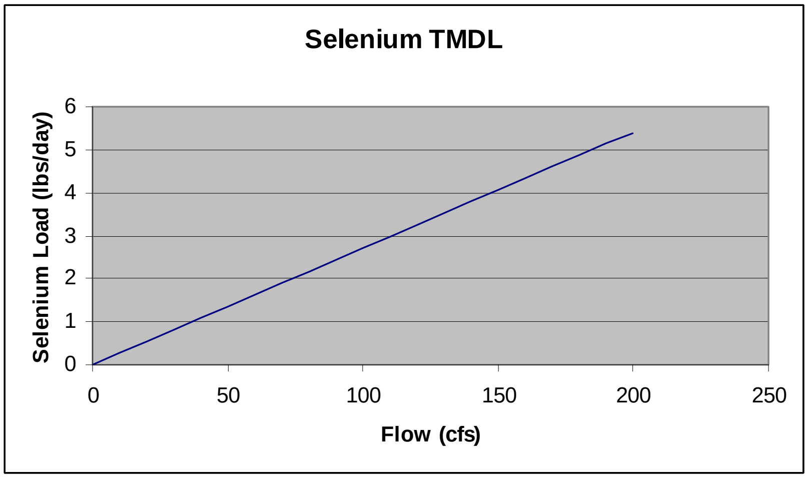


Figure 7-7. Selenium TMDL curve that illustrates how the TMDL changes with flow.

Table 7-43. Example metals TMDLs for water bodies in the Upper Clark Fork TPA without storm event data.
“--" indicates no data.

Stream Segment	Station	Discharge (cfs)		Hardness		Metal	Target Conc (µg/L)		TMDL (lbs/day)		Percent Load Reduction Based on Sampled Target Exceedance	
		High flow	Low flow	High flow	Low flow		High flow	Low flow	High flow	Low flow	High flow	Low flow
Beefstraight Creek (MT76G003_031)	BS-D	30	3.6	N/A		Cyanide	5.2	5.2	0.842	0.101	78%	76%
Dunkleberg Creek (MT76G005_071)	DNK-5	3.61	1.36	131	173	Arsenic	10	10	0.195	0.073	0%	0%
						Cadmium	0.33	0.41	0.006	0.003	82%	0%
						Copper	11.75	14.9	0.229	0.109	16%	0%
						Iron	1000	1000	19.494	7.344	72%	0%
						Lead	4.49	6.39	0.088	0.047	96%	43%
						Zinc	150.62	190.64	2.936	1.400	32%	0%
Dunkleberg Creek (MT76G005_072)	DNK-9	8	3[1]	119	150[1]	Arsenic	10	10	0.432	0.162	33%	--
						Cadmium	0.31	0.37	0.013	0.006	0%	--
						Copper	10.82	13.19	0.467	0.214	55%	--
						Iron	1000	1000	43.200	16.200	28%	--
						Lead	3.97	5.33	0.172	0.086	32%	--
						Zinc	138.84	168.93	5.998	2.737	0%	--
German Gulch (MT76G003_030)	STA-3A	1.2	0.21	N/A		Arsenic	10	10	0.065	0.011	29%	9%
						Selenium	5	5	0.032	0.006	38%	62%
	STA-1	42	5.3			Cyanide	5.2	5.2	1.179	0.149	48%	68%
Gold Creek (MT76G005_091)	GLD-04	39.59	3.54	42	65.9	Lead	1.05	1.87	0.224	0.036	0%	0%
Gold Creek (MT76G005_092)	GLD-09	87.17	6.89	99	267	Iron	1000	1000	470.718	37.206	29%	0%
						Lead	3.14	11.11	1.478	0.413	0%	0%
Peterson Creek (MT76G002_131)	PTR-06	20.52	0.46	39	84	Copper	4.17	8.04	0.462	0.020	40%	0%
						Iron	1000	1000	110.808	2.484	39%	0%
						Lead	0.96	2.55	0.106	0.006	36%	0%
Peterson Creek (MT76G002_132)	PTR-14	11.55	0.12	103	262	Iron	1000	1000	62.370	0.648	52%	0%

[1] Low flow discharge and hardness values are estimated because no low flow samples were collected.

Table 7-44. Example metals TMDLs for water bodies in the Upper Clark Fork TPA with storm event data.

"--" indicates no data.

Stream Segment	Station	Discharge (cfs)			Hardness			Metal	Target Conc (µg/L)			TMDL (lbs/day)			Percent Load Reduction Based on Sampled Target Exceedance		
		Storm flow[1]	High flow	Low flow	Storm flow	High flow	Low flow		Storm flow	High flow	Low flow	Storm flow	High flow	Low flow	Storm flow	High flow	Low flow
Lost Creek (MT76G002_072)	Galen gage/ LC-5 (storm)	0.659	11	2.4	N/A	N/A	N/A	Arsenic	10	10	10	0.036	0.594	0.130	89%	29%	60%
	Anaconda gage/LC-2 (storm)	0.61	15	0.97	108	84	110	Copper	9.96	8.04	10.12	0.033	0.651	0.053	85%	57%	0%
								Lead	3.51	2.55	3.59	0.012	0.207	0.019	64%	9%	0%
Mill Creek (MT76G002_051)	MC-5	4.385	68.93	5.51	50.8	28.9	76.3	Arsenic	10	10	10	0.237	3.722	0.298	36%	0%	0%
								Cadmium	0.16	0.11	0.22	0.004	0.041	0.007	83%	31%	0%
								Copper	5.23	3.23	7.4	0.124	1.202	0.220	88%	0%	0%
								Lead	1.34	0.66	2.25	0.032	0.246	0.067	92%	18%	0%
								Zinc	67.5	41.85	95.28	1.598	15.577	2.835	22%	56%	0%
Mill Creek (MT76G002_052)	Opportunity gage (high and low) MC-10A (storm)	2.62	110	1.5	76	32	86	Arsenic	10	10	10	0.141	5.940	0.081	79%	80%	71%
								Cadmium	0.22	0.12	0.24	0.003	0.071	0.002	49%	86%	0%
								Copper	7.38	3.52	8.2	0.104	2.091	0.066	50%	91%	0%
								Iron	1000	1000	1000	14.148	594.000	8.100		49%	0%
								Lead	2.24	0.75	2.63	0.032	0.446	0.021	65%	94%	0%
								Zinc	94.96	45.63	105.44	1.343	27.104	0.854	50%	0%	0%
Mill-Willow Bypass (MT76G002_120)	MWB-2	--	214	8.77	--	95	200	Arsenic	--	10	10	--	11.556	0.474	--	71%	55%
								Cadmium	--	0.26	0.45	--	0.300	0.021	--	0%	0%
								Copper	--	8.93	16.87	--	10.320	0.799	--	50%	0%
								Lead	--	2.98	7.69	--	3.444	0.364	--	38%	0%
								Zinc	--	114.72	215.57	--	132.570	10.209	--	0%	0%
Modesty Creek (MT76G002_080)	MDS-4 (high and low) MOD-4 (storm)	1.5	3.69	6.38	152	378	319	Arsenic	10	10	10	0.081	0.199	0.345	57%	23%	29%
								Cadmium	0.37	0.72	0.64	0.003	0.014	0.022	23%	0%	0%
								Copper	13.34	29.06	25.14	0.1081	0.579	0.866	48%	0%	0%
								Lead	5.42	17.29	13.93	0.0439	0.345	0.480	45%	0%	0%
Warm Springs Creek (MT76G002_012)	Warm Springs gage (high and low) WS-5 (storm)	50	94	40	108	130	150	Arsenic	10	10	10	2.7	5.076	2.160	34%	55%	22%
								Cadmium	0.29	0.33	0.37	0.0783	0.168	0.080	42%	20%	0%
								Copper	9.96	11.67	13.19	2.6892	5.924	2.849	87%	89%	0%
								Iron	1000	1000	1000	270	507.600	216.000	--	41%	0%
								Lead	3.51	4.44	5.33	0.9477	2.254	1.151	63%	57%	0%
								Zinc	127.89	149.64	168.93	34.53	75.957	36.489	0%	0%	0%
Willow Creek (MT76G002_061)	WLW-05 (high and low) WC-13 (storm)	0.8	98	1.27	44	31	40	Arsenic	10	10	10	0.0432	5.292	0.069	86%	58%	29%
								Cadmium	0.15	0.11	0.14	0.0006	0.058	0.001	63%	0%	0%
								Copper	4.63	3.43	4.26	0.02	1.815	0.029	87%	76%	0%
								Iron	1000	1000	1000	4.32	529.200	6.858	--	51%	0%
								Lead	1.12	0.72	0.99	0.0048	0.381	0.007	82%	90%	0%
								Zinc	59.76	44.42	55.12	0.2582	23.507	0.378	16%	0%	0%
Willow Creek (MT76G002_062)	WLW-11 (high and low) WC-15 (storm)	10.3	74.21	5.85	128	83	142	Arsenic	10	10	10	0.5562	4.007	0.316	66%	87%	23%
								Cadmium	0.32	0.24	0.35	0.0178	0.096	0.011	0%	8%	0%
								Copper	11.52	7.96	12.59	0.6407	3.190	0.398	40%	74%	0%
								Iron	1000	1000	1000	55.62	400.734	31.590	--	0%	0%
								Lead	4.36	2.51	4.97	0.2425	1.006	0.157	52%	69%	0%
								Zinc	147.69	102.32	161.27	8.2145	41.003	5.095	0%	0%	0%

[1] Flow data was not available for all storm events and some values were estimated based on available data

7.6 Loading Summary and Allocations

In the sections that follow, a loading summary and source allocation is provided for each pollutant-water body combination with a TMDL. Loading summaries are based on the sample data provided in **Section 7.4.4** and contained in **Appendix D**. For water body segments that flow through a Superfund Site, the loading summaries also incorporate conclusions drawn as part of the Superfund RI process. As part of the RI, numerous source assessment and loading studies have been conducted that incorporate ground water and surface water pathways. These findings are critical components of the remedial actions that have occurred and are planned for the future, and will aid in TMDL implementation, but many of the details are not discussed because they are beyond the scope of TMDL development. The aim of the loading summaries is to discuss seasonal loading trends and significant loading sources and pathways.

As discussed in **Section 4.0**, a TMDL is the sum of all of the load allocations (LAs), waste load allocations (WLAs), and a margin of safety (MOS). LAs are allowable pollutant loads assigned to nonpoint sources and may include the cumulative pollutant load from naturally occurring and human caused sources. When possible, separate LAs are provided to naturally occurring sources and anthropogenic sources. The most common human caused nonpoint sources in the Upper Clark Fork TPA are atmospheric deposition and sediment and soils contaminated by historic mining activity. WLAs are allowable pollutant loads that are assigned to point sources (permitted and non-permitted). Waste sources associated with historic mining such as adit discharges, tailings, and waste rock piles are considered non-permitted point sources (and subject to a WLA). Where adequate data are available to evaluate loading from individual mining sources, these non-permitted point sources will be given separate WLAs. Otherwise, the contribution from all abandoned mines (e.g. adits, waste rock, tailings) in a contributing area or entire watershed is grouped into a composite WLA from abandoned mines. In watersheds with abandoned mines where historic atmospheric deposition and/or other diffuse mining wastes are the primary source(s) of metals loading and the contribution from abandoned mines cannot be separated from the diffuse sources, the sources will be given a composite LA. As part of the adaptive management approach discussed in **Section 10.0**, source refinement is recommended for abandoned mines, and those included within a composite LA or addressed by composite WLAs may be given separate WLAs in the future pending additional data collection.

As discussed in **Section 4.0**, all TMDLs incorporate a MOS. Metals TMDLs in this document apply an implicit MOS through the adoption of a variety of conservative assumptions in calculating TMDLs and estimating pollutant loads. These assumptions are described in more detail in **Section 7.7.2**.

7.6.1 Beefstraight Creek (MT76G003_031)

Loading Summary

High and low flow target exceedances for cyanide in Beefstraight Creek are the result of cyanide heap leach mining at Beal Mountain Mine. Approximately 182 million gallons of biologically treated waste was land applied to a 31 acre area between 2001 and 2005 (**Figure A-23**). In 2008, leachate was treated via reverse osmosis and land applied. Analysis of the reverse osmosis effluent indicates that the process results in cyanide concentrations around 10µg/L, which is almost double the chronic aquatic life criterion (Tetra Tech, 2009). However, the effluent is stored in a pond prior to land application, and monitoring by the USFS indicates the cyanide degrades to concentrations less than target concentrations within the pond (Tetra Tech, 2009). Ammonia is a by-product of cyanide degradation, and although this document does not address nutrients, ammonia and other forms of nitrogen may be an issue at the mine site and should be evaluated.

The USFS has extensively studied surface water, ground water, and spring concentrations within the Beefstraight Creek watershed as part of mine reclamation. Investigation of the land application area concluded that leachate that is land applied migrates to ground water and then to seeps and springs that flow directly to surface water (Tetra Tech, 2009), including Beefstraight Creek and two of its major tributaries, American Gulch and Minnesota Gulch (**Figure A-23**). No surface water samples have been collected in American Gulch since 2003, but cyanide concentrations from samples in Minnesota Gulch (MINN-DN), the drainage collection pond (BCD-A), and Beefstraight Creek (BS-D) have all decreased in magnitude since 2005. However, samples from springs near the mine show a different trend. At four different springs within the land application area and downgradient of the heap leach pad (**Figure A-23**), several samples were collected in 2003 and a single sample was collected in June 2008. Three of the springs had a maximum concentration in 2008 (concentration range = 27 - 45µg/L), and one spring (SPR-19) had a lower concentration in 2008 than in 2003 but a concentration greater than other springs in the area (250µg/L). At a spring near the confluence of Minnesota Gulch and Beefstraight Creek (SPR-D8), it was dry in 2006 but in 2005 when the last sample was collected, it had one of the higher concentrations for that site (121µg/L). Because the concentration of cyanide in treated leachate meets water quality targets prior to land application, this suggests that elevated concentrations in the ground water and recent target exceedances in Beefstraight Creek are predominantly the result of historical land application of treated leachate.

Although the majority of the leachate is treated, there is some potential for untreated leachate to reach ground and/or surface water. A potential source of cyanide from untreated leachate is the pond that collects drainage from the leach pad underdrain (BCD-A) and overflows occasionally during spring runoff onto a hill that slopes toward Minnesota Gulch. Although the hill is well vegetated, it is within the land application boundary (**Figure A-23**) and therefore has the potential to contribute to target exceedances by migrating to Minnesota Gulch and ultimately Beefstraight Creek via surface runoff or ground water.

Although the exact loading mechanism of cyanide to Beefstraight Creek is not well understood and may shift seasonally, it all originates with heap leach waste from Beal Mountain Mine.

TMDLs and Allocations

Because cyanide loading to Beefstraight Creek is associated with Beal Mountain Mine, a waste load allocation to Beal Mountain Mine ($WLA_{Beefstraight}$) will be provided. Background concentrations are less than the detection limit (5µg/L), which is close to the water quality target (5.2µg/L); because cyanide is generally a man-made substance, the allocation to naturally occurring sources of cyanide ($LA_{BeefstraightNat}$) will be calculated using half of the detection limit. Using half of the detection limit to calculate the background load is conservative and part of the implicit MOS. Other implicit considerations for the MOS are discussed in **Section 7.7.2**. The cyanide TMDL components are summarized below and **Table 7-45** shows cyanide TMDLs and allocations for measured high and low flow conditions in the Beefstraight Creek watershed. This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards.

$\mathbf{TMDL_{Beefstraight} = WLA_{Beefstraight} + LA_{BeefstraightNat}}$
$\mathbf{MOS_{Beefstraight} = Implicit}$

Table 7-45. Cyanide TMDLs and load allocation example for Beefstraight Creek at BS-D.

Metal	**Flow Conditions**	**TMDL (lbs/day)**	**Percent Reduction Needed**	**$LA_{BeefstraightNat}$ (lbs/day)**	**$WLA_{Beefstraight}$ (lbs/day)**
Cyanide	High flow	0.842	78%	0.405	0.437
	Low flow	0.101	76%	0.049	0.052

Although a TMDL is being written for Beefstraight Creek, USFS sampling data indicates water quality targets are also periodically not being met in two of its tributaries, Minnesota Gulch and possibly American Gulch. It is anticipated that the TMDL for Beefstraight Creek will not be met without also meeting water quality targets in these tributaries, but it is recommended that reclamation activities to meet the Beefstraight Creek TMDL also aim to meet water quality targets in its tributaries.

7.6.2 Dunkleberg Creek, Upper Segment (MT76G005_071)

Loading Summary

Target exceedances occurred at high and low flow for cadmium and lead and at high flow for copper, iron, and zinc. During high flow, concentrations decreased slightly for cadmium, lead, and zinc and increased for copper and iron between the upper and lower end of the segment (i.e. between sites DNK-01 and DNK-05). During low flow, all metals decreased between DNK-01 and DNK-05. For cadmium and lead, high and low flow target exceedances occurred just downstream of Forest Rose mine at DNK-01 and at the tributary site downstream of Jackson Park mine, DNK-03, indicating both priority abandoned mines (and potentially other abandoned mines in the area) are contributing to target exceedances in the upper segment of Dunkleberg Creek. Although the copper and zinc concentration were elevated at DNK-01 during high and low flow sampling events, because the target for both metals is positively correlated to hardness and hardness decreases downstream, the only exceedance of the copper and zinc target is at the lower end of the segment (DNK-05) during high flow. The target for iron is not hardness-dependent, however, and target exceedances occurred during high flow at both DNK-01 and DNK-05.

If loads are calculated based on measured flow and sample concentrations, the sum of the loads at DNK-01 and at tributary sites DNK-02 and DNK-03 is much less than the measured load at DNK-05 during high flow and much greater than the measured load at DNK-05 during low flow. There are sample sites on both tributaries within this segment and there are no other mining sources identified within the mining databases along Dunkleberg Creek downstream of Forest

Rose Mine. This suggests that some of the load may precipitate and/or settle out between the upper and lower part of the segment during low flow and be re-suspended during high flow. Between site DNK-03 and DNK-05, the valley gradient lessens from greater than 4 percent to between 2 and 4 percent, which indicates a transition from a transport-dominated system to a more depositional system. Because cadmium and lead were the only metals with target exceedances during low flow, the measured "loss" in load during low flow was compared to the measured "gain" during high flow between the upper and tributary sites (DNK-01, -02, -03) and the lower site (DNK-05). To compare the difference, it was assumed that the measured change in load during sampling represents a daily change, low flow occurs for nine months, and high flow occurs for two months. Based on this, the loss/gain ratio for cadmium is 2:1 and for lead is 1:1. This is a very rough calculation but it suggests that the load lost during low flow may account for the increased load during high flow. Additional monitoring is suggested to help further characterize loading in the upper segment.

Although there were no arsenic target exceedances, the sediment concentrations downstream of Forest Rose Mine at DNK-01 were 14 times greater than the supplemental indicator value, whereas concentrations at other sites along the segment were less than twice the supplemental indicator value, suggesting that the Forest Rose Mine is the primary source of elevated arsenic in the upper segment.

TMDLs and Allocations

The Forest Rose Mine and Jackson Park Mine have been identified as separate source areas and will be given separate composite WLAs ($\mathbf{WLA_{FR}}$ and $\mathbf{WLA_{JP}}$). Although the priority abandoned mines have been identified as the primary sources, other abandoned mines within the vicinity of each priority abandoned mine are included in the composite WLAs. For the $\mathbf{WLA_{JP}}$, the allocation includes Jackson Park Mine and other abandoned mine sources on the unnamed tributary near Jackson Park (i.e. upstream of DNK-03; **Figure A-24**). The $\mathbf{WLA_{FR}}$ includes Forest Rose Mine and other abandoned mine sources in the upper watershed (excluding those addressed by $\mathbf{WLA_{JP}}$). Metals concentrations at DNK-02, a tributary site, are assumed to represent background and will be used to calculate the load allocation to naturally occurring sources ($\mathbf{LA_{UppDunkNat}}$). Where the concentration at DNK-02 was below the detection limit, the allocation is calculated using the detection limit because the actual concentration is unknown and using a concentration at the detection limit to estimate naturally occurring metals loads incorporates an implicit MOS in addition to the measures discussed in **Section 7.7.2**.

The $\mathbf{WLA_{JP}}$ is calculated using the flow of the unnamed tributary near Jackson Park Mine (DNK-03) relative to the contribution from upper Dunkleberg Creek (DNK-01 and DNK-02) to the flow at DNK-05. The $\mathbf{WLA_{FR}}$ is calculated by subtracting the sum of the $\mathbf{LA_{UppDunkNat}}$ and $\mathbf{WLA_{JP}}$ from the TMDL ($\mathbf{TMDL_{UppDunk}}$). The TMDL components are summarized below.

$\mathbf{TMDL_{UppDunk} = WLA_{FR} + WLA_{JP} + LA_{UppDunkNat}}$
$\mathbf{MOS_{UppDunk}}$ **= Implicit**

Table 7-46. Metals TMDLs and allocation example for upper Dunkleberg Creek at DNK-05.

Metal	Flow Conditions	TMDL (lbs/day)	Percent Reduction Needed	$LA_{UppDunkNat}$ (lbs/day)	WLA_{JP} (lbs/day)	WLA_{FR} (lbs/day)
Arsenic	High flow	0.195	0%	0.058	0.043	0.094
	Low flow	0.073	0%	0.022	0.041	0.011
Cadmium	High flow	0.006	82%	0.002	0.001	0.003
	Low flow	0.003	0%	0.001	0.002	0.0002
Copper	High flow	0.229	16%	0.019	0.050	0.159
	Low flow	0.109	0%	0.007	0.060	0.042
Iron	High flow	19.494	72%	5.653	4.266	9.575
	Low flow	7.344	0%	0.367	4.050	2.927
Lead	High flow	0.088	96%	0.012	0.019	0.057
	Low flow	0.047	43%	0.004	0.026	0.017
Zinc	High flow	2.936	32%	0.195	0.643	2.099
	Low flow	1.400	0%	0.147	0.772	0.481

Example high and low flow TMDLs and allocations for upper Dunkleberg Creek (**Table 7-46**) are based on recent high and low flow conditions. Because no water column exceedances occurred for arsenic in recent samples, that TMDL example requires no reductions. However, it is assumed based on elevated sediment metals concentrations that there are water column exceedances not captured in the sample data set. Restoration activities to reduce metals loads are expected to also address sediment-related toxicity and metals-related impairment to beneficial uses. This allocation scheme assumes applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards.

7.6.3 Dunkleberg Creek, Lower Segment (MT76G005_072)

Loading Summary

The abandoned mine databases do not indicate any abandoned mines along the lower segment of Dunkleberg Creek. As discussed in **Section 7.6.2**, target exceedances at the upstream end of the lower segment (near DNK-05) are attributable to loading from the Forest Rose and Jackson Park priority abandoned mines as well as non-priority abandoned mines in the upper watershed. Other than loading from abandoned mines in upper Dunkleberg Creek, the irrigation ditch that withdraws from the Clark Fork River (see **Figures 7-2** and **A-24**) is contributing to target exceedances in the lower segment of Dunkleberg Creek.

Both during high and low flow sampling events, discharge from several tributaries to the lower segment almost doubles the flow between DNK-05 and DNK-08 (just upstream of the ditch from the Clark Fork River) and results in attainment of water quality targets at DNK-08. However, loading from the ditch that withdraws from the Clark Fork River and mixes with Dunkleberg Creek downstream of DNK-08 resulted in exceedances of arsenic, copper, iron, and lead targets during high flow sampling. As discussed in the evaluation of existing data (**Section 7.4.4.3**), a comparison of data from the Clark Fork River gage near Gold Creek indicates target exceedances for the same metals during high flow in 2008. Although no low flow data is available at DNK-09, low flow data from the Clark Fork River gage suggests that the ditch may result in exceedances of the arsenic target exceedance during low flow. Additional monitoring is recommended within the lower segment of Dunkleberg Creek, including the ditch, to further characterize metals loading to the lower segment.

TMDLs and Allocations

The ditch that withdraws from the Clark Fork River is considered a significant source of metals loading, and as an unpermitted point source to the lower segment of Dunkleberg Creek, it is provided a waste load allocation ($\mathbf{WLA_{DunkDitch}}$). It is acknowledged that loading via the ditch from the Clark Fork River may decrease as remediation occurs for tributary sources in the Upper Clark Fork TPA but may not be fully attained until TMDL implementation occurs on the mainstem Clark Fork River. The other waste load allocations, $\mathbf{WLA_{FR}}$ and $\mathbf{WLA_{JP}}$, are to unpermitted point sources in the upper portion of the watershed and are discussed in more detail in the TMDL discussion for the upper segment of Dunkleberg Creek (**Section 7.6.2**). The load allocation to naturally occurring sources ($\mathbf{LA_{DunkNat}}$) is calculated based on flow at DNK-09 and using metals concentrations from a tributary in the upper watershed (DNK-02) that are assumed to represent the background condition. The $\mathbf{WLA_{DunkDitch}}$ is calculated by subtracting the LA and other WLAs from the TMDL. The MOS is addressed through implicit considerations (see **Section 7.7.2**).

The TMDL components are summarized below and **Table 7-47** shows example TMDLs and allocations for measured high and low flow conditions in the Dunkleberg Creek watershed. This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards.

$$\mathbf{TMDL_{LowerDNK} = WLA_{DunkDitch} + WLA_{FR} + WLA_{JP} + LA_{DunkNat}}$$
$$\mathbf{MOS_{LowerDNK} = Implicit}$$

Table 7-47. Metals TMDLs and allocation example for lower Dunkleberg Creek.
“--" indicates no data available for percent reduction calculation.

TMDLs for Dunkleberg Creek at DNK-09				Allocations			
Metal	**Flow Conditions**	**TMDL (lbs/day)**	**Percent Reduction Needed**	**$LA_{DunkNat}$ (lbs/day)**	**$WLA_{DunkDitch}$ (lbs/day)**	**WLA_{JP} (lbs/day)**	**WLA_{FR} (lbs/day)**
Arsenic	High flow	0.432	33%	0.130	0.166	0.043	0.094
	Low flow	0.162	--	0.049	0.062	0.041	0.011
Cadmium	High flow	0.013	0%	0.003	0.005	0.001	0.003
	Low flow	0.006	--	0.002	0.002	0.002	0.0002
Copper	High flow	0.467	55%	0.043	0.215	0.050	0.159
	Low flow	0.214	--	0.016	0.095	0.060	0.042
Iron	High flow	43.200	28%	12.528	16.831	4.266	9.575
	Low flow	16.200	--	0.810	8.413	4.050	2.927
Lead	High flow	0.172	32%	0.026	0.070	0.019	0.057
	Low flow	0.086	--	0.008	0.035	0.026	0.017
Zinc	High flow	5.998	0%	0.432	2.825	0.643	2.099
	Low flow	2.737	--	0.324	1.159	0.772	0.481

7.6.4 German Gulch (MT76G003_030)

Loading Summary

Target exceedances for arsenic, selenium, and cyanide are all associated with Beal Mountain Mine. This section will include a brief summary of spatial and hydrologic (i.e. flow-related) trends in concentrations and loading for arsenic, selenium, and cyanide in German Gulch. The Engineering Evaluation/Cost Analysis for Beal Mountain Mine contains a more detailed evaluation and discussion of loading sources within the mine site (Tetra Tech, 2009) and will be used as the basis for much of the reclamation activities at the site.

Water quality targets in German Gulch were predominantly exceeded during low flow. Generally, low flow exceedances are associated with a relatively constant source such as ground water or a point source. Concentrations of all constituents met the targets upstream of the mine (STA-4) and had the greatest number of exceedances at sites STA-3 and STA-3A, which are located just downstream of the mine (**Figure A-23**).

For arsenic, all exceedances of water quality targets occurred at STA-3 and STA-3A, and when both sites were sampled on the same day, the concentration decreased between the stations, indicating most arsenic is entering German Gulch upstream of STA-3. The adit sampled upstream of STA-3 prior to the operation of the Beal Mountain Mine had an arsenic concentration of 70µg/L, indicating historical mining likely resulted in oxidation of arsenic-bearing rocks and contributed to arsenic loading within German Gulch. Arsenic concentrations in sediment are greatest near the mine (GRM-01) and decrease in a downstream direction with a slight increase near the mouth (GRM-05). The increase in sediment concentrations near the mouth could be from upstream sources that have been flushed downstream to lower gradient areas but could also be related to smelter emissions and mine wastes associated with the Silver Bow-Butte Area Superfund Site. Because all arsenic target exceedances are in the upper watershed, addressing sources mining sources in the upper watershed should address sediment that is transported downstream, and remedial actions within the Streamside Tailings Operable Unit of the Silver Bow-Butte Area Superfund Site (**Figure A-19**) should decrease sediment arsenic concentrations near the mouth, the arsenic TMDL will focus on sources in the upper watershed.

All target exceedances for selenium occur upstream of the confluence with Beefstraight Creek and selenium concentrations in the stream sediment near the mine (GRM-01) are almost twice that found at the next site two miles downstream (GRM-02) and continue to decrease in a downstream direction. This indicates that mining at Beal Mountain Mine and potentially historical mining in the same area are the primary sources of selenium loading to German Gulch. As part of mine reclamation, synoptic sampling and a dye tracer study was conducted in 2002 and 2003 to assess selenium sources and loading (Jepson, 2002; Gurrieri, 2003). The studies indicated that the primary source of selenium is waste rock at the site. There is a pipeline that routes discharge from a drain at the toe of the waste rock dump, two seeps under the waste rock, and the main Beal Pit drain into an infiltration gallery in the alluvium along German Gulch between STA-3A and STA-2. Of these sources, the seeps and pit drain each contribute just over 20 percent of the load and the toe drain contributes almost 60 percent of the load. Although the infiltration gallery results in loading downstream of STA-3A, the greatest and most frequent target exceedances occur at STA-3 and STA-3A. Additional sources within this area primarily reach German Gulch via ground water and include seepage from the waste rock that may not be captured by the toe drain, a road upstream of STA-3 that was constructed from waste rock, and part of the dike in the leach pad that was built from waste rock.

Although cyanide target exceedances occurred both upstream and downstream of the confluence with Beefstraight Creek, most of the cyanide loading to German Gulch is from Beefstraight Creek because of the location of the land application area (**Figure A-23**). Because cyanide quickly breaks down in the environment, the measured load downstream of Beefstraight Creek at STA-1A was typically 20-40% less than the sum of the loads measured upstream of the confluence at sites BS-D and STA-2. Therefore, to assess loading from Beal Mountain Mine directly to German Gulch versus Beefstraight Creek, the relative difference between loads at STA-2 and BS-D was compared. With the exception of snowmelt sampling events, Beefstraight Creek typically contributes between 70 and 80 percent of the flow to German Gulch at STA-1A, and during the period when biologically treated leachate was land applied (i.e. 2003-2005), it typically contributed between 75 and 95 percent of the load at STA-1A. Because of the increasing number of samples below the detection limit since 2005, it is difficult to compare loading to Beefstraight Creek and upper German Gulch for 2006 and 2008. However, loading to German Gulch is expected to continue via the same pathways because historical land application of leachate has resulted in elevated concentrations in the ground water (as discussed in **Section 7.6.1**) and because the leach pad continues to have elevated cyanide concentrations that may migrate to ground water and eventually reach German Gulch (Tetra Tech, 2009). Because no additional cyanide is being used, leachate in the leach pad is being treated and decreaseing the concentration in the pad, and because leachate treated by reverse osmosis is below target concentrations when applied (Tetra Tech, 2009), the magnitude of loading is anticipated to decease over time.

TMDLs and Allocations

Collectively, sources of arsenic, cyanide, and selenium include numerous springs and seeps, a land application system that discharges treated leachate from a pipe, and a pipeline that collects discharge from waste rock and other sources before releasing it into an infiltration gallery within the alluvium along German Gulch. These sources are all separate unpermitted point sources but because they all relate to the same mine, the Beal Mountain Mine itself will be considered a single point source and given a WLA ($\mathbf{WLA_{German}}$). Some of the arsenic and selenium is also likely the result of historic placer, hydraulic, and lode mining within the upper watershed. Contributions from these sources cannot be separated from Beal Mountain Mine and are also included within the WLA.

Because the greatest target exceedances for arsenic and selenium occurred at STA-3 and STA-3A, the example TMDLs and allocation examples in **Table 7-49** are based on high and low flow data at STA-3A, which is farther downstream than STA-3. For cyanide, however, loading to German Gulch is occurring upstream of STA-3A but is predominantly from the Beefstraight Creek watershed, resulting in target exceedances downstream of the confluence of Beefstraight Creek and German Gulch at STA-1. Therefore, the TMDL and allocation example for cyanide in **Table-49** is based on high and low flow data at STA-1.

For arsenic and selenium, the $\mathbf{WLA_{German}}$ is calculated by subtracting the load allocation to naturally occurring sources ($\mathbf{LA_{GermanNat}}$) from the TMDL. Because the cyanide TMDL includes loading from Beefstraight Creek, it includes all allocations to Beefstraight Creek ($\mathbf{TMDL_{Beefstraight}}$), a waste load allocation to German Gulch ($\mathbf{WLA_{German}}$), and a load allocation to naturally occurring sources (excluding those addressed by the Beefstraight allocations). The $\mathbf{LA_{German}}$ is calculated using the background concentrations discussed in **Section 7.4.4.4** for STA-4, upstream of Beal Mountain Mine. As part of the implicit MOS, the highest measured background concentration will be used to calculate the LA for each constituent as shown in **Table 7-48**. Additional considerations for the implicit MOS are discussed in **Section 7.7.2**.

Table 7-48. Equation for computing the load allocations for German Gulch.

Metal	$\mathbf{LA_{GermanNat}}$
Arsenic	4µg/L * Flow (at STA-3A)* 0.0054
Cyanide	2.5µg/L * Flow (at STA-1 minus the flow from Beefstraight Creek) * 0.0054
Selenium	3µg/L * Flow (at STA-3A) * 0.0054

The TMDL components are summarized below. This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards.

For arsenic and selenium: $\mathbf{TMDL_{German} = WLA_{German}} + \mathbf{LA_{GermanNat}}$

For cyanide: $\mathbf{TMDL_{German} = WLA_{German} + LA_{GermanNat}} + \mathbf{TMDL_{Beefstraight}}$

$\mathbf{MOS_{German} = Implicit}$

Table 7-49. Metals TMDLs and allocation example for German Gulch.

TMDLs for German Gulch at STA-3A (As and Se) & STA-1 (CN)				**Allocations (lbs/day)**		
Metal	**Flow Conditions**	**TMDL (lbs/day)**	**Percent Reduction Needed**	$\mathbf{WLA_{German}}$ **(lbs/day)**	$\mathbf{LA_{GermanNat}}$ **(lbs/day)**	$\mathbf{TMDL_{Beefstraight}}$ **(lbs/day)**
Arsenic	High flow	0.065	29%	0.039	0.026	N/A
	Low flow	0.011	9%	0.0065	0.0045	
Selenium	High flow	0.032	500%	0.013	0.019	
	Low flow	0.006	62%	0.003	0.003	
Cyanide	High flow	1.179	48%	0.175	0.162	0.842
	Low flow	0.149	68%	0.025	0.023	0.101

7.6.5 Gold Creek, Upper Segment (MT76G005_091)

Loading Summary

Because of the limited dataset and that lead concentrations at both sites on the upper segment of Gold Creek were less than the detection limit for lead (0.5µg/L) during high and low flow sampling, there is no summary of metals loading for upper Gold Creek. However, the upper segment of Gold Creek is listed for lead and a TMDL is being developed based on that and the source assessment in **Section 7.4.4.5**.

TMDLs and Allocations

Although additional monitoring is recommended for upper Gold Creek to better characterize the water quality and refine the source assessment, there are numerous abandoned mines in the upper watershed, and the abandoned mine assessment files note tailings ponds, unstable waste rock dumps, and/or tailings near the channel in association with several of the mines. All of these potential sources are associated with abandoned mines and considered unpermitted point sources. Therefore, a composite WLA ($\mathbf{WLA_{UppGold}}$) will be provided to address the cumulative pollutant load from abandoned mines in the upper Gold Creek watershed. The $\mathbf{WLA_{UppGold}}$ is calculated by subtracting the LA to naturally occurring sources ($\mathbf{LA_{UppGoldNat}}$) from the TMDL. The $\mathbf{LA_{UppGoldNat}}$ is calculated using concentrations from the North Fork of Gold Creek (GLD-03), which has no known abandoned mines and is assumed to represent the background condition. Background lead concentrations at GLD-03 during high and low were less than the detection limit (0.5µg/L), but the detection limit is used to calculate the $\mathbf{LA_{UppGoldNat}}$ because the actual concentration is unknown and using a concentration at the detection limit to estimate naturally occurring metals loads incorporates an implicit MOS in addition to the measures discussed in **Section 7.7.2**.

The TMDL components are summarized below and **Table 7-50** shows example TMDLs and allocations for measured high and low flow conditions in the upper Gold Creek watershed. Although the TMDL is for upper Gold Creek, the source assessment indicated that abandoned mines may be contributing to water quality target exceedances in tributaries within the upper watershed; as part of the WLA, water quality targets should also be met within tributaries to Gold Creek. This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards.This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards.

$\mathbf{TMDL_{UppGold} = WLA_{UppGold} + LA_{UppGoldNat}}$
$\mathbf{MOS_{UppGold} = Implicit}$

Table 7-50. Lead TMDL and load allocation example for upper Gold Creek at GLD-04.

Metal	**Flow Conditions**	**TMDL (lbs/day)**	**Percent Reduction Needed**	**$WLA_{UppGold}$ (lbs/day)**	**$LA_{UppGoldNat}$ (lbs/day)**
Lead	High flow	0.224	0%	0.118	0.107
	Low flow	0.036	0%	0.026	0.010

7.6.6 Gold Creek, Lower Segment (MT76G005_092)

Loading Summary

Water quality target exceedances for iron occurred at both high and low flow. One target exceedance during high flow was near the mouth but the other exceedances were on the tributary of Blum Creek (GLD-06). With the exception of GLD-06, water samples were analyzed for total suspended solids (TSS). During high flow, TSS was less than the detection limit (10mg/L) at the upper end of the segment and at the tributary site on Pikes Peak Creek, but was six times greater than the detection limit at the mouth. The increase in TSS and the water quality target exceedance on Blum Creek suggest the iron exceedance near the mouth during high flow is associated with sediment either in the channel or transported via runoff and is likely the result of sources on Blum Creek. However, a loading mass balance indicates inputs from additional sources, which could include abandoned mines on other tributaries or along lower Gold Creek; if the high flow iron load at the upper part of the segment is summed with the load from the two tributary sites, it only accounts for 46 percent of the load measured near the mouth of Gold Creek. During low flow sampling, there was an iron water quality target exceedance on Blum Creek, but all TSS samples were less than the detection limit (10mg/L), suggesting the exceedance may be associated with a discrete source of dissolved iron. The only target exceedance for lead occurred on Blum Creek during high flow; therefore, it is probably associated with the same source that contributed to elevated iron concentrations during high flow and is likely associated with sediment.

Based on the available data, metals loading from the upper segment is minimal and water quality target exceedances in the lower watershed are primarily from abandoned mine sources along lower Gold Creek and its tributaries. The limited dataset suggests that lead loading is primarily occurring during high flow and associated with sediment but because iron exceedances occurred during high and low flow, iron loading may be associated with sediment during runoff and also with ground water or a discrete source associated with the mines. Although target exceedances were only observed near the mouth of Gold Creek and on Blum Creek, the distribution of abandoned mines throughout the watershed, the potential sources indicated in the abandoned mine assessment files, and the water quality data collectively indicate sources on Gold Creek and along several of its tributaries may contribute to water quality target exceedances.

TMDLs and Allocations

Because the source assessment indicates sources of metals loading associated with abandoned mines on several tributaries, as well as Gold Creek, composite WLAs will be provided to address cumulative loading from abandoned mines by contributing source area. As shown in **Figure A-25**, the source areas are as follows:

- Blum Creek
- Pikes Peak Creek
- Upper Gold Creek
- Remainder of the lower Gold Creek watershed

As a result of irrigation and losses in streamflow in the lower watershed, flow cannot be used as a basis for the allocations. Because watershed area and stream discharge within a subwatershed are roughly proportional to that of its watershed (Moreau et al., 1998), the size of each of the four source areas relative to the Gold Creek watershed is used to derive its WLA. As shown in **Table 7-51**, each WLA comprises its percentage of the Gold Creek watershed multiplied by the difference between the TMDL (**$\mathbf{TMDL_{Gold}}$**) and the LA to naturally occurring sources (**$\mathbf{LA_{GoldNat}}$**). The **$\mathbf{LA_{GoldNat}}$** is calculated using concentrations from the North Fork of Gold Creek (GLD-03), which is a tributary to the upper segment of Gold Creek that has no abandoned mines indicated in the databases and is assumed to represent the background condition. Background lead concentrations at GLD-03 during high and low flow were less than the detection limit (0.5µg/L), but the detection limit is used to calculate the **$\mathbf{LA_{GoldNat}}$** for lead because the actual concentration is unknown and using a concentration at the detection limit to estimate naturally occurring lead loads incorporates an implicit MOS. Also, as part of the implicit MOS, the highest measured background iron concentration (190µg/L) will be used to calculate the LA for iron. Additional considerations for the implicit MOS are discussed in **Section 7.7.2**.

Table 7-51. Calculation of source area WLAs for the lower Gold Creek metals TMDLs.

Source Area	Percentage of Gold Creek Watershed	$\mathbf{WLA = TMDL_{Gold} - LA_{GoldNat}}$
Blum Creek	7%	$WLA_{Blum} = 0.07*(TMDL_{Gold} – LA_{Gold})$
Pikes Peak Creek	41%	$WLA_{PPeak} = 0.41*(TMDL_{Gold} – LA_{Gold})$
Upper Gold Creek	27%	$WLA_{UppGold} = 0.27*(TMDL_{Gold} – LA_{Gold})$
Remainder of the lower Gold Creek watershed	25%	$WLA_{LowGold} = 0.25*(TMDL_{Gold} – LA_{Gold})$

The TMDL components are summarized below and **Table 7-52** shows example TMDLs and allocations for measured high and low flow conditions in the lower Gold Creek watershed. Note, the **$\mathbf{WLA_{UppGold}}$** for lead is conceptually the same as the WLA for the upper segment of Gold Creek provided in **Section 7.6.5**, but because TMDLs and allocations vary with flow and water hardness, the examples contain different numbers. Although the TMDL is for Gold Creek, the water quality data indicates target exceedances are also occurring in tributaries; as part of the WLAs, water quality targets should also be met within the contributing source areas. This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards.

$\mathbf{TMDL_{Gold} = LA_{GoldNat} + (WLA_{Blum} + WLA_{PPeak} + WLA_{UppGold} + WLA_{LowGold})}$
MOS = Implicit

Table 7-52. Metals TMDLs and allocation example for lower Gold Creek at GLD-09.

Metal	Flow Conditions	TMDL (lbs/day)	Percent Reduction Needed	$LA_{GoldNat}$ (lbs/day)	WLA_{Blum} (lbs/day)	WLA_{PPeak} (lbs/day)	$WLA_{UppGold}$ (lbs/day)	$WLA_{LowGold}$ (lbs/day)
Iron	High flow	470.718	29%	89.436	26.690	156.325	102.946	95.320
	Low flow	37.206	0%	7.069	2.110	12.356	8.137	7.534
Lead	High flow	1.478	0%	0.235	0.087	0.510	0.336	0.311
	Low flow	0.413	0%	0.019	0.028	0.162	0.107	0.099

7.6.7 Lost Creek, Lower Segment (MT76G002_072)

Loading Summary

Because arsenic is highly soluble and mobile, it exhibits different trends than copper and lead, the other metals of concern in the Lost Creek watershed. Generally, arsenic concentrations increased in a downstream direction and were greatest downstream of LC-2/Anaconda gage, which corresponded to the majority of water quality exceedances occurring at the Galen gage. Also, arsenic concentrations were almost 100 percent dissolved and although target exceedances occurred at all flows, concentrations were typically greatest during low flow, suggesting ground water or a discrete point source. The abandoned mine assessment files did not indicate any potential point sources in the watershed, but the Anaconda Superfund Site ROD identified ground water metals contamination resulting from smelter fallout (EPA and DEQ, 1998). Most copper and lead water quality target exceedances occurred during high flow or storm events in the upper part of the segment near the Anaconda gage and concentrations were attenuated downstream, and exceedances were primarily associated with particulates, suggesting most copper and lead loading is associated with surface runoff and/or mobilization of sediments within the channel. Although copper and lead concentrations increased slightly downstream during low flow, which may be associated with ground water inputs, hardness also typically increased threefold between the gaging stations, resulting in higher water quality targets and no exceedances near the mouth.

Lower Lost Creek is heavily used for irrigation withdrawals, which is indicated by the downward summertime shift in average daily flow between the Anaconda and Galen gages (**Figure 7-8**). During the irrigation season, lower Lost Creek receives return flows from Gardiner Ditch (30-50cfs), which originates at Warm Springs Creek, and it also receives major ground water inputs, which can exceed 40cfs over the 8 miles downstream of LC-2/Anaconda gage (**Figure A-26**) (Pioneer Technical Services, Inc., 2002). Storm event sampling indicates that significant loading for all metals occurs in the vicinity of LC-2/Anaconda gage and from a tributary that drains the north slope of Stuckey Ridge and flows into Gardiner Ditch. Loading from other tributaries that contributes to target exceedances is limited to high flow and storm events. During low flow, arsenic inputs downstream of LC-2 are likely associated with the large influx of ground water. Return flows from Gardiner Ditch also likely constitute some low flow loading of arsenic, and possibly other metals, but sampling in 1993 showed a doubling in flow in the vicinity of the ditch but a decrease in load, indicating that Gardiner Ditch may actually dilute arsenic concentrations within Lost Creek. This is consistent with a 1995 RI report for the Anaconda Superfund site that concluded that Gardiner Ditch has a minimal impact on metals concentrations in Lost Creek (Environmental Science and Engineering, Inc., 1995). Overall, these trends in loading correspond with a 2002 mass loading study that concluded the primary sources of elevated metals concentrations in Lost Creek are surface runoff and ground water (Pioneer Technical Services, Inc., 2002). Ground water inputs to Lost Creek were identified as originating from the Stuckey Ridge and Dutchman Creek areas. Because the bedrock aquifer is fractured in the Stuckey Ridge area, there is a TI there for the arsenic human health standard (EPA, 1996). Although the primary loading mechanism differs for arsenic than other metals, the source assessment indicates that the metals are all associated with historic atmospheric deposition and mining wastes.

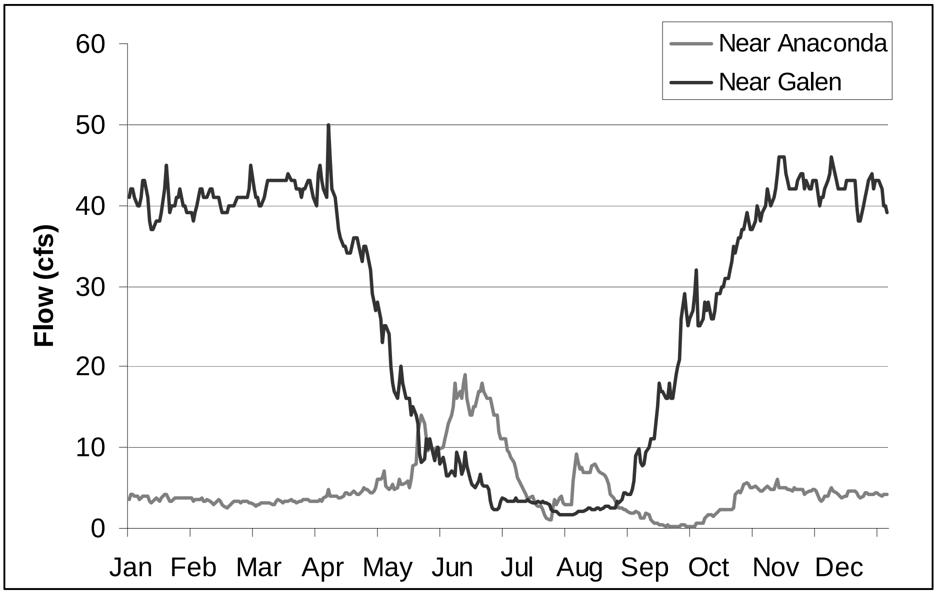


Figure 7-8. Average daily discharge at the gaging stations on Lost Creek.

TMDLs and Allocations

Metals loading to Lost Creek is associated with atmospheric deposition from the Anaconda Smelter and other diffuse historical mining sources that migrate to the creek via both surface runoff and ground water. Therefore, no WLA will be provided to Lost Creek. A composite load allocation is provided to historic mining sources and wastes (**LA_{Lost}**). The **LA_{Lost}** is calculated by subtracting the load allocation to naturally occurring sources (**$LA_{LostNat}$**) from the TMDL. Although **LA_{Lost}** addresses the entire Lost Creek watershed, implementation is expected to be achieved by focusing remediation on the sources in the lower watershed discussed in the loading summary. It is acknowledged that even if the migration of metals to ground water which flows into Lost Creek is eliminated or mitigated, particularly for arsenic, it may take much longer for concentrations in the ground water to decrease. Although the source assessment indicates metals loading is primarily associated with historic atmospheric deposition, because of the presence of abandoned mines in the upper watershed, the source assessment should be refined as discussed in **Section 10.0** and WLAs may be necessary in the future via adaptive management if additional monitoring indicates discrete abandoned mining sources are also contributing to metals impairment in Lost Creek.

Although the databases indicate abandoned mines within the upper watershed in the Beaverhead Deerlodge National Forest, the area has not been identified as affected by smelter fallout, and concentrations of all metals at LST-01, just downstream of the Lost Creek State Park boundary, were low during low and high flow sampling. Therefore, the concentrations at LST-01 are assumed to represent background conditions and are used to calculate the load allocation to naturally occurring sources (**$LA_{LostNat}$**). Background arsenic and lead concentrations at LST-01 during high and low flow were less than the detection limit (As = 3µg/L, Pb = 0.5µg/L), but the detection limit is used to calculate the **$LA_{LostNat}$** because the actual concentration is unknown and using a concentration at the detection limit to estimate naturally occurring lead loads incorporates an implicit MOS. Also, as part of the implicit MOS, the highest measured background copper concentration (2µg/L) will be used to calculate the LA for copper. Additional considerations for the implicit MOS are discussed in **Section 7.7.2**.

The TMDL components are summarized below and shows example TMDLs and allocations for measured storm event and high and low flow conditions in the Lost Creek watershed. This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards. Note, as discussed in **Section 7.4.1.2**, Lost Creek is a water body where a TI waiver of the arsenic drinking water standard may occur; if a TI waiver occurs for arsenic (or other metals), it means that it is not technically feasible to remediate sources to the extent that water quality will meet the applicable water quality standard, and the TMDL will not be met. If this occurs, the relevant water quality target(s) and TMDL(s) may need to be modified via adaptive management, which is discussed in detail in **Section 7.8**.

$TMDL_{Lost} = LA_{Lost} + LA_{LostNat}$
WLA_{Lost} = NA
MOS_{Lost} = Implicit

Table 7-53. Metals TMDLs and allocation example for Lost Creek.

TMDLs at Galen gage/LC-5 (storm) for As and at Anaconda gage/LC-2 (storm) for Cu and Pb			**Allocations**		
Metal	**Flow Conditions**	**TMDL (lbs/day)**	**Percent Reduction Needed**	**LA_{Lost} (lbs/day)**	**$LA_{LostNat}$ (lbs/day)**
Arsenic	Storm event	0.036	89%	0.025	0.011
	High flow	0.594	29%	0.416	0.178
	Low flow	0.130	60%	0.091	0.039
Copper	Storm event	0.033	85%	0.026	0.007
	High flow	0.651	57%	0.489	0.162
	Low flow	0.053	0%	0.043	0.010
Lead	Storm event	0.012	64%	0.010	0.002
	High flow	0.207	9%	0.166	0.041
	Low flow	0.019	0%	0.016	0.003

7.6.8 Mill Creek, Upper Segment (MT76G002_051)

Loading Summary

The timing of water quality target exceedances predominantly during high flow and storm events combined with low sediment metals concentrations indicates overland flow is likely the primary pathway for metals loading to the upper segment of Mill Creek. Tributary samples from Ceanothus Creek and Muddy Creek, which flow into Mill Creek just downstream of the upper segment, had metals concentrations much greater than in Mill Creek at all flows and suggest tributaries may be a source of metals loading; however, because there was only sampling site in the upper segment, loading source areas cannot be evaluated and additional monitoring is recommended to refine the source assessment.

TMDLs and Allocations

Metals loading to upper Mill Creek is associated with atmospheric deposition from the Anaconda Smelter and other diffuse historical mining sources that migrate to the creek via both storm runoff and ground water. Therefore, no WLA will be provided to the upper segment of Mill Creek. The TMDL consists of two load allocations: one composite allocation to historic mining sources and wastes ($\mathbf{LA_{UppMill}}$) and one allocation to naturally occurring sources ($\mathbf{LA_{UppMillNat}}$). The $\mathbf{LA_{UppMill}}$ is calculated by subtracting $\mathbf{LA_{UppMillNat}}$ from the TMDL. The MOS is addressed through implicit considerations (see **Section 7.7.2**).

The load allocation to naturally occurring conditions ($\mathbf{LA_{UppMillNat}}$) is calculated using concentrations from site C01MILLC02 (**Figure A-27**) because it is assumed to represent the background condition; the site is upstream of the tributaries that originate along Mount Haggin and is not close to any abandoned mines indicated in the databases. Background metals concentrations at C01MILLC02 were less than the detection limit (e.g. As = 3µg/L, Cd = 0.1µgL, Cu = 1µg/L, Pb = 0.5µg/L, Zn = 10µg/L), but the detection limit is used to calculate the $\mathbf{LA_{UppMillNat}}$ because the actual concentration is unknown and using a concentration at the detection limit to estimate naturally occurring lead loads incorporates an implicit MOS. Background concentrations were only sampled during low flow and may be higher during high flow conditions. Additional monitoring should be conducted during high flow to assess naturally occurring conditions at high flow, and the $\mathbf{LA_{UppMillNat}}$ may need to be modified in the future via adaptive management if data indicate the background concentration differs at high flow.

The TMDL components are summarized below and **Table 7-54** shows example TMDLs and allocations for measured storm event and high and low flow conditions in the upper Mill Creek watershed. It is acknowledged that even if the migration of metals to ground water which flows into Mill Creek and its tributaries is eliminated or mitigated, particularly for arsenic, it may take much longer for concentrations in the ground water to decrease. This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards. Note, as discussed in **Section 7.4.1.2**, Mill Creek is a water body where a TI waiver of the arsenic drinking water standard may occur; if a TI waiver occurs for arsenic (or other metals), it means that it is not technically feasible to remediate sources to the extent that water quality will meet the applicable water quality standard, and the

TMDL will not be met. If this occurs, the relevant water quality target(s) and TMDL(s) may need to be modified via adaptive management, which is discussed in detail in **Section 7.8**.

$TMDL_{UppMill}$ = $LA_{UppMill}$ + $LA_{UppMillNat}$
$WLA_{UppMill}$ = NA
$MOS_{UppMill}$ = Implicit

Table 7-54. Metals TMDLs and allocation example for upper Mill Creek at MC-5.

Metal	**Flow Conditions**	**TMDL (lbs/day)**	**Percent Reduction Needed**	**$LA_{UppMillNat}$ (lbs/day)**	**$LA_{UppMill}$ (lbs/day)**
Arsenic	Storm event	0.237	36%	0.071	0.166
	High flow	3.722	0%	1.117	2.606
	Low flow	0.298	0%	0.089	0.208
Cadmium	Storm event	0.004	83%	0.002	0.001
	High flow	0.041	31%	0.037	0.004
	Low flow	0.007	0%	0.003	0.004
Copper	Storm event	0.124	88%	0.024	0.100
	High flow	1.202	0%	0.372	0.830
	Low flow	0.220	0%	0.030	0.190
Lead	Storm event	0.032	92%	0.012	0.020
	High flow	0.246	18%	0.186	0.060
	Low flow	0.067	0%	0.015	0.052
Zinc	Storm event	1.598	22%	0.237	1.362
	High flow	15.577	56%	3.722	11.855
	Low flow	2.835	0%	0.298	2.537

7.6.9 Mill Creek, Lower Segment (MT76G002_052)

Loading Summary

Although some metals loading comes from the upper segment of Mill Creek, additional metals loading to the lower segment of Mill Creek results in increased concentrations in a downstream direction with target exceedances occurring more frequently near the mouth at the Opportunity gage than the Anaconda gage. Similar to the upper segment of Mill Creek, arsenic concentrations are elevated during all flows, but most loading for the other metals of concern (i.e. copper, cadmium, iron, lead, and zinc) occurs during high flow and storm events and is associated with particulates. However, particulates do contribute to high flow arsenic water quality target exceedances in lower Mill creek; samples at the Anaconda gage have a consistent ratio of dissolved arsenic during all flows but at the Opportunity gage near the mouth, a greater percentage of the arsenic values are associated with particulates during high flow.

Arsenic concentrations were similar downstream of the Anaconda gage and were elevated at tributary sites during all flow conditions, but during low flow, concentrations of cadmium, copper, and lead were only elevated at tributary sites. Because no discrete sources are known, this indicates that ground water strongly influences arsenic concentrations in Mill Creek and concentrations of numerous metals in its tributaries. During all flows, the majority of arsenic loading comes from tributaries, particularly those that originate along Mount Haggin or the edge of Smelter Hill (**Figure A-27**). Although much of the metals loading during storm events and high flow is associated with runoff from Smelter Hill and Mount Haggin, some water quality exceedances were limited to sites near the mouth (despite similar hardness values and resulting water quality targets along the segment), indicating additional loading from sources along Mill Creek near Opportunity. The loading trends are consistent with the Anaconda Superfund Site ROD, which cited the primary metals pathways as runoff and ground water in the tributaries of Clear Creek, Cabbage Gulch, and Aspen Hills, with some inputs from streamside waste (EPA and DEQ, 1998).

TMDLs and Allocations

There are some abandoned mines within the watershed, but their influence cannot be separated from that of the smelter or other diffuse sources. However, the source assessment indicates that metals loading to lower Mill Creek is primarily associated with atmospheric deposition from the Anaconda Smelter and other diffuse historical mining sources. Therefore, no WLA will be provided. However, because of the presence of abandoned mines near Smelter Hill, the source assessment should be refined as discussed in **Section 10.0** and WLAs may be necessary in the future via adaptive management if additional monitoring indicates discrete abandoned mining sources are also contributing to metals impairment in Mill Creek. The TMDL consists of two load allocations: one to composite allocation to historic mining sources and wastes ($\mathbf{LA_{Mill}}$) and one allocation to naturally occurring sources ($\mathbf{LA_{MillNat}}$). The $\mathbf{LA_{Mill}}$ is calculated by subtracting $\mathbf{LA_{MillNat}}$ from the TMDL. The MOS is addressed through implicit considerations (see **Section 7.7.2**).

The load allocation to naturally occurring conditions ($\mathbf{LA_{MillNat}}$) is calculated using concentrations from site C01MILLC02 (**Figure A-27**) because it is assumed to represent the background condition; the site is upstream of the tributaries that originate along Mount Haggin and is not close to any abandoned mines indicated in the databases. Background metals concentrations at C01MILLC02 were less than the detection limit (e.g. As = 3µg/L, Cd = 0.1µgL, Cu = 1µg/L, Fe = 10 µg/L, Pb = 0.5µg/L, Zn = 10µg/L), but the detection limit is used to calculate the $\mathbf{LA_{MillNat}}$ because the actual concentration is unknown and using a concentration at the detection limit to estimate naturally occurring lead loads incorporates an implicit MOS. Background concentrations were only sampled during low flow and may be higher during high flow conditions. Additional monitoring should be conducted during high flow to assess naturally occurring conditions at high flow, and the $\mathbf{LA_{MillNat}}$ may need to be modified in the future via adaptive management if data indicate the background concentration differs at high flow.

The TMDL components are summarized below and **Table 7-55** shows example TMDLs and allocations for measured storm event and high and low flow conditions in the lower Mill Creek watershed. Although the TMDL is for lower Mill Creek, target exceedances are also occurring in tributaries, and implementation is expected to include addressing these sources during remediation and result in water quality target attainment in Mill Creek and its tributaries. It is acknowledged that even if the migration of metals to ground water which flows into Mill Creek and its tributaries is eliminated or mitigated, particularly for arsenic, it may take much longer for concentrations in the ground water to decrease. This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards. Note, as discussed in **Section 7.4.1.2**, Mill Creek is a water body where a TI waiver of the arsenic drinking water standard may occur; if a TI waiver occurs for arsenic (or other metals), it means that it is not technically feasible to remediate sources to the extent that water quality will meet the applicable water quality standard, and the TMDL will not be met. If this occurs, the relevant water quality target(s) and TMDL(s) may need to be modified via adaptive management, which is discussed in detail in **Section 7.8**.

$\mathbf{TMDL_{Mill} = LA_{Mill} + LA_{MillNat}}$
$\mathbf{WLA_{Mill} = NA}$
$\mathbf{MOS_{Mill} = Implicit}$

Table 7-55. Metals TMDLs and allocation example for lower Mill Creek.
“--" denotes no data available to calculate a percent reduction.

TMDLs at Opportunity gage (high and low) and MC-10A (storm)				**Allocations**	
Metal	**Flow Conditions**	**TMDL (lbs/day)**	**Percent Reduction Needed**	**LAMillNat (lbs/day)**	**LAMill (lbs/day)**
Arsenic	Storm event	0.141	79%	0.042	0.099
	High flow	5.940	80%	1.782	4.158
	Low flow	0.081	71%	0.024	0.057
Cadmium	Storm event	0.003	49%	0.001	0.002
	High flow	0.071	86%	0.059	0.012
	Low flow	0.002	0%	0.001	0.001
Copper	Storm event	0.104	50%	0.014	0.090
	High flow	2.091	91%	0.594	1.497
	Low flow	0.066	0%	0.008	0.058
Iron	Storm event	14.148	--	0.141	14.007
	High flow	594.000	49%	5.94	588.060
	Low flow	8.100	0%	0.081	8.019
Lead	Storm event	0.032	65%	0.007	0.025
	High flow	0.446	94%	0.297	0.149
	Low flow	0.021	0%	0.004	0.017
Zinc	Storm event	1.343	50%	0.141	1.202
	High flow	27.104	0%	5.940	21.164
	Low flow	0.854	0%	0.081	0.773

7.6.10 Mill-Willow Bypass (MT76G002_120)

Loading Summary

Mill and Willow creeks, which form the bypass (**Figure A-28**), are the primary inputs to the Mill-Willow Bypass, but additional potential sources of metals loading include ground water seepage from the Warm Springs Ponds (via the toe drains and seepage under the toe drains), ground water from the Opportunity Ponds area, and historic mining wastes dispersed within the stream channel. Flow data are only available for MWB-1, the most upstream site, but loading studies have identified roughly a 6 cfs gain from ground water along the bypass, with approximately 0.4 cfs (i.e. less than 10 percent) of that coming from the toe drain system (Gammons et al., 2007; Gammons, 2007). As discussed in the loading summaries for Mill and Willow creeks (**Sections 7.6.9** and **7.6.16**, respectively), metals loading for all metals of concern is greatest during high flow/storm events, and is associated with particulate fractions, but arsenic concentrations tend to remain elevated during low flow because of ground water contributions. Within the Warm Springs Ponds, loads of arsenic and other metals are also greatest during snowmelt and high flow, but arsenic concentrations tend to peak during summer months when biological activity causes bound arsenic to become soluble and released to the water column (Environmental Science and Engineering, Inc., 1995). Overall, metals concentrations in the Mill-Willow Bypass reflected the trends in Mill and Willow creeks; metals of concern were greatest during high flow and arsenic was the only metal that remained elevated during low flow. Gage data were compared to assess relative loading from Mill and Willow creeks, and although Willow Creek generally had greater metals concentrations during high flow, it also typically had less discharge at that time. Neither creek consistently or seasonally contributed a dominant proportion of the metals loads, and this is likely a factor of snowmelt occurring at different rates, changes in flow and loading because of irrigation, and dispersed sources with loading controlled by numerous factors.

Within the bypass, concentrations were typically fairly static or decreased slightly between MWB-1 and MWB-2 (**Figure A-28**), indicating most loading is from Mill and Willow creeks. Concentrations did periodically increase between the two sites, however, and although there was no flow data for MWB-2 to assess loading within the bypass, other data sources indicate additional arsenic loading to the bypass via ground water. Samples from the pipe drains between the Warm Springs Ponds and the Mill Willow Bypass were analyzed for all COCs but the only elevated metal was arsenic (average concentration between 1998 and 2004 = 66µg/L) (Environmental Science and Engineering, Inc., 1995). A study of arsenic loading during low flow in 2005 observed an increase in arsenic concentration along the bypass that translated to a 20 percent increase in load one day and a 71 percent increase in load the following day (Gammons, 2007). Given the small flow contribution from the pipe drains, it was estimated that less than 10 percent of the load increase could be attributed to outflow from the drains. Based on isotope data and the chemical composition of water (i.e. conductivity) in the Mill-Willow Bypass relative to nearby ground water wells, it was hypothesized that ground water seepage from the Warm Springs Ponds is a more significant source of arsenic to the bypass than ground water from the Opportunity Ponds and arsenic loading could be a result of leakage from Ponds 2 and 3 that interacted with buried mine wastes or from mobilization from the streambed (Gammons et al., 2007; Gammons, 2007).

TMDLs and Allocations

Although some loading to the Mill-Willow Bypass is associated with pipe drains, they are not considered a point source; the pipe drains were installed during channel reconstruction to relieve ground water pressure against the soil-cement layer that covers the bypass side of the dike (between the bypass and Warm Springs Ponds) and to maintain the stability of the dike (EPA, 2005). A composite load allocation (**$\mathbf{LA_{MWB}}$**) will be used to address the cumulative loading from the pipe drains, as well as other ground water and in-channel sources associated with historic mining. In addition to the LAMWB, the TMDL consists of the TMDL allocations to Mill Creek **(LA_{Mill}** + **$LA_{MillNat}$**) and Willow Creek **(LA_{Willow}** + **$LA_{WillowNat}$**). Because the allocations to Mill and Willow creeks address naturally occurring sources and the only flow inputs along the bypass are associated with ground water, the LAMWB also addresses naturally occurring sources along the length of the bypass. The MOS is addressed through implicit considerations (see **Section 7.7.2**).

The TMDL components are summarized below and **Table 7-56** shows example TMDLs and allocations based on measured concentrations during high and low flow conditions in the Mill-Willow Bypass. Flows for the example TMDLs were based on flows used in the example TMDLs for Mill and Willow creeks plus 6 cfs for the typical ground water gain between MWB-1 and MWB-2 (**Table 7-44**). This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards. Note, as discussed in **Section 7.4.1.2**, the Mill-Willow Bypass is a water body where a TI waiver of the arsenic drinking water standard may occur; if a TI waiver occurs for arsenic (or other metals), it means that it is not technically feasible to remediate sources to the extent that water quality will meet the applicable water quality standard, and the TMDL will not be met. If this occurs, the relevant water quality target(s) and TMDL(s) may need to be modified via adaptive management, which is discussed in detail in **Section 7.8**.

$TMDL_{MWB} = LA_{MWB} + TMDL_{Mill} + TMDL_{Willow}$
WLA_{MWB} = NA
MOS_{MWB} = Implicit

Table 7-56. Metals TMDLs and allocation example for the Mill-Willow Bypass at MWB-2.

Metal	Flow Conditions	TMDL (lbs/day)	Percent Reduction Needed	LAMWB (lbs/day)	TMDLMill (lbs/day)	TMDLWillow (lbs/day)
Arsenic	High flow	11.556	71%	1.609	5.940	4.007
	Low flow	0.474	55%	0.077	0.081	0.316
Cadmium	High flow	0.300	0%	0.133	0.071	0.096
	Low flow	0.021	0%	0.008	0.002	0.011
Copper	High flow	10.320	50%	5.039	2.091	3.190
	Low flow	0.799	0%	0.335	0.066	0.398
Lead	High flow	3.444	38%	1.992	0.446	1.006
	Low flow	0.364	0%	0.186	0.021	0.157
Zinc	High flow	132.570	0%	64.463	27.104	41.003
	Low flow	10.209	0%	4.260	0.854	5.095

7.6.11 Modesty Creek (MT76G002_080)

Loading Summary

Because of extensive irrigation in the Modesty Creek watershed, metals loading is difficult to assess. The watershed is known to be affected by atmospheric deposition from the Anaconda Smelter (personal comm. C. Coover, 2009), and the associated elevated soils metals concentrations are evident in storm event samples that exceeded water quality targets for arsenic, cadmium, copper, and lead. During high and low flow sampling, however, arsenic was the only elevated metal in Modesty Creek. In the mid-watershed (MOD-5, **Figure A-30**), the entire flow was withdrawn for irrigation during high flow, but arsenic concentrations were elevated and entirely dissolved both upstream of the dewatered area and near the mouth, where irrigation return flows from Racetrack, Lost, and Warm Springs creeks constitute most of the flow in Modesty Creek. The arsenic concentrations and water hardness values were similar at high and low flow near the mouth, and hardness values, which are based on the concentration of calcium and magnesium and are strongly influenced by ground water inputs, were multiple times greater near the mouth than at the mid-watershed site. Although the dataset is limited, these trends suggest that with the exception of storm and high flow events that erode upland soils, most metals loading is associated with ground water inputs or irrigation returns, which may also largely contain ground water inputs. Regardless of whether loading occurs via overland flow or ground water, the initial source of elevated metals within the watershed is atmospheric deposition associated with the Anaconda Smelter.

Water quality data near the mouth combined with data from two of the irrigation return flows to lower Modesty Creek indicates that ditches constitute a source of metals loading to Modesty Creek. A sample of return flow from Gardiner Ditch, which withdraws from Warm Springs Creek, was elevated for arsenic and copper, and a composite sample from two Racetrack Creek ditches was elevated for copper. By the time return flows from Gardiner Ditch enter Modesty Creek, however, the ditch has flowed for almost 10 miles and flowed through the Lost Creek and Warm Springs Creek watersheds, which are both affected by atmospheric deposition and other historical mining sources. The composite sample from the Racetrack Creek ditches is not elevated for arsenic, which is the typical signature for watersheds affected by atmospheric deposition from the Ananconda Smelter (personal comm. C. Coover, 2009). Although the copper concentration in the ditches exceeds the water quality target associated with low hardness values in the ditches, it is nowhere close to the water quality target in Modesty Creek at the time of sampling, which had a hardness value four times greater. Additional monitoring of Racetrack Creek is suggested, but based on the low metals concentrations in the ditch, especially relative to water quality targets in Modesty Creek, it is assumed to be an insignificant source of loading to Modesty Creek. No samples were collected from the ditch return flow from Lost Creek, but because Lost Creek is also impaired by metals as a result of atmospheric deposition and historical mining sources (**Section 7.4.4.7**), it may also be a source of metals loading to Modesty Creek. Based on the sample from Gardiner Ditch and historical mining sources in both the Lost Creek and Warm Springs Creek watersheds, ditch returns from Gardiner Ditch and Lost Creek are probable sources of metals, particularly arsenic. However, TMDLs are presented within this document for both Lost Creek and Warm Springs Creek (**Sections 7.6.7**. and **7.6.14**, respectively) and remediation efforts should address sources within those watersheds that contribute to elevated metals concentrations within irrigation ditches and reduce loading to Modesty Creek associated with irrigation return flows.

TMDLs and Allocations

Metals loading to Modesty Creek is associated with atmospheric deposition from the Anaconda Smelter and other diffuse historical mining sources. Therefore, no WLA will be provided to Modesty Creek. Because of the smelter fallout and extensive irrigation in upper Modesty Creek, a naturally occurring load cannot be established. The total load allocation for Modesty Creek ($\mathbf{LA_{Modesty}}$) is equal to the TMDL and is allocated to the combined load from naturally occurring and historic mining-related sources. Although TMDLs for Lost Creek and Warm Springs Creek should address loading to the irrigation ditches originating in those watersheds, the ditches may also receive metals inputs from within the Modesty Creek watershed and those sources are expected to be addressed via the $\mathbf{LA_{Modesty}}$. The MOS is addressed through implicit considerations (see **Section 7.7.2**). Additional monitoring is recommended, possibly in a nearby watershed with similar geology, to determine naturally occurring conditions. If a naturally occurring load can be established, the TMDL may be need to be modified via adaptive management to provide separate LAs to historic mining sources and naturally occurring sources.

The TMDL components are summarized below and **Table 7-57** shows example TMDLs and allocations for measured storm event and high and low flow conditions in the Modesty Creek watershed. Note, the high flow examples contain lower loads than the low flow examples because irrigation resulted in lower flow during the "high flow" period. This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards. Note, as discussed in **Section 7.4.1.2**, Modesty Creek is a water body where a TI waiver of the arsenic drinking water standard may occur; if a TI waiver occurs for arsenic (or other metals), it means that it is not technically feasible to remediate sources to the extent that water quality will meet the applicable water quality standard, and the TMDL will not be met. If this occurs, the relevant water quality target(s) and TMDL(s) may need to be modified via adaptive management, which is discussed in detail in **Section 7.8**.

$\mathbf{TMDL_{Modesty} = LA_{Modesty}}$
$\mathbf{WLA_{Modesty} = NA}$
$\mathbf{MOS_{Modesty} = Implicit}$

Table 7-57. Metals TMDLs and load allocation example for Modesty Creek.

TMDLs and Load Allocations at MDS-4 (high/low) and MOD-4 (storm)			
Metal	**Flow Conditions**	**TMDL/ $LA_{Modesty}$ (lbs/day)**	**Percent Reduction Needed**
Arsenic	Storm event	0.081	57%
	High flow	0.199	23%
	Low flow	0.345	29%
Cadmium	Storm event	0.003	23%
	High flow	0.014	0%
	Low flow	0.022	0%
Copper	Storm event	0.108	48%
	High flow	0.579	0%
	Low flow	0.866	0%
Lead	Storm event	0.044	45%
	High flow	0.345	0%
	Low flow	0.480	0%

7.6.12 Peterson Creek, Upper Segment (MT76G002_131)

Loading Summary

All water quality target exceedances occurred during high flow, suggesting metals loading to upper Peterson Creek is associated with runoff and erosion of historic mining sources and/or re-suspension of sediment within the channel. However, as discussed in the source assessment (**Section 7.4.4.12**), several of the abandoned mines are near springs or surface water; therefore, metals loading during low flow may also contribute to water quality issues that were not observed in the limited dataset. Flow near the headwaters was only 5 percent of flow at the lower end of the segment, and metals loads near the headwaters were between 3 and 4 percent of the measured load at the lower end of the segment, indicating most of the loading is attributable to sources downstream of the headwaters. Based on the source assessment, the sources could include placer mining, tailings associated with abandoned mines, and sediment associated with historic mining that is trapped within beaver complexes and released during high flow.

TMDLs and Allocations

Because of historic mining in the headwaters and resulting elevated metals concentrations, the naturally occurring load cannot be established. Cumulative loading from all historic mining sources and naturally occurring sources will be addressed via a composite WLA (**$WLA_{UppPeterson}$**). This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards. The MOS is addressed through implicit considerations (see **Section 7.7.2**). Additional monitoring is recommended, possibly in a nearby watershed with similar geology, to determine naturally occurring conditions. If a naturally occurring load can be established, the TMDL may need to be modified via adaptive management to provide separate allocations to historic mining sources (i.e. composite WLA) and to naturally occurring sources (i.e. LA).

The TMDL components are summarized below and **Table 7-58** shows example TMDLs and allocations for measured high and low flow conditions in the upper Peterson Creek watershed.

$TMDL_{UppPeterson}$ = $WLA_{UppPeterson}$
$LA_{UppPeterson}$ = NA
$MOS_{UppPeterson}$ = Implicit

Table 7-58. Metals TMDLs and allocation example for the upper segment of Peterson Creek at PTR-06.

Metal	Flow Conditions	$TMDL/WLA_{UppPeterson}$ (lbs/day)	Percent Reduction Needed
Copper	High flow	0.462	40%
	Low flow	0.020	0%
Iron	High flow	110.808	39%
	Low flow	2.484	0%
Lead	High flow	0.106	36%
	Low flow	0.006	0%

7.6.13 Peterson Creek, Lower Segment (MT76G002_132)

Loading Summary

As discussed in the data review in **Section 7.4.4.13**, the only iron water quality target exceedance occurred during high flow and was associated with particulates, and the iron concentration increased by 28 percent over the lower segment as the flow decreased by almost half. This suggests that although water is withdrawn within the lower segment, the concentration increases either as a factor of the diversions concentrating particulates within the channel or because of additional sources. The water quality target was also exceeded at the downstream end of the upper segment, indicating the upper watershed is a source of iron loading. However, a load calculation suggests that iron loading within the lower segment is sufficient enough to result in water quality target exceedances even if the TMDL is met for the upper segment. Based on the sampling data, the iron load decreased by 28 percent over the lower segment, and if the concentration at the upper sampling site met the water quality target (i.e. 1000µg/L) and the load decreased by 28 percent, the iron concentration at the mouth would be exceeding the water quality target at 1,279µg/L.

TMDLs and Allocations

Because of historic mining in the headwaters and resulting elevated metals concentrations in both the upper and lower segments of Peterson Creek, the naturally occurring load cannot be established. Cumulative loading from all historic mining sources and naturally occurring sources will be addressed via a composite WLA (**$WLA_{Peterson}$**). This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards. The MOS is addressed through implicit considerations (see **Section 7.7.2**). Additional monitoring is recommended, possibly in a nearby watershed with similar geology, to determine naturally occurring conditions. If a naturally occurring load can be established, the TMDL may need to be modified via adaptive management to provide separate allocations to historic mining sources (i.e. composite WLA) and to naturally occurring sources (i.e. LA).

The TMDL components are summarized below and **Table 7-59** shows example TMDLs and allocations for measured high and low flow conditions in the lower Peterson Creek watershed.

$TMDL_{Peterson}$ = $WLA_{Peterson}$
$LA_{Peterson}$ = NA
$MOS_{Peterson}$ = Implicit

Table 7-59. Metals TMDLs and allocation example for the upper segment of Peterson Creek at PTR-14.

Metal	**Flow Conditions**	**$TMDL/WLA_{Peterson}$ (lbs/day)**	**Percent Reduction Needed**
Iron	High flow	62.370	52%
	Low flow	0.648	0%

7.6.14 Warm Springs Creek, Lower Segment (MT76G002_012)

Loading Summary

At the gaging stations, all metals water quality target exceedances occurred at the Warm Springs gage, indicating most of the metals loading is occurring downstream of Anaconda, which coincides with the area of interest for the Anaconda Superfund RI (CDM, 2007; CDM, 2009). As discussed in **Section 7.4.4.14**, in addition to receiving smelter fallout, there are numerous areas of historic mining wastes in and along Warm Springs Creek, and trends in metals water quality target exceedances in the lower segment are consistent with the dispersed nature of the sources; sites with elevated metals concentrations varied by sampling event and the greatest metals concentrations for each sampling event frequently occurred at different sites for each metal. However, some generalizations can be made regarding source areas.

In general, most metals loading during high flow occurred between Galen Road and the mouth (WS-3 to WS-5, **Figure A-32**). Much of the Superfund-related data do not have corresponding flow measurements, but during all flow conditions, metals concentrations typically remained static or decreased between WS-5 and WS-6/Warm Springs gage, suggesting limited additional metals loading downstream of WS-5. The only surface water input in the area where most metals loading was observed is the North Ditch. During high flow sampling in 2008, the North Ditch (which collects ground water from the north side of the Opportunity Ponds) was sampled and all concentrations were low, which is consistent with sampling done in 1993 and indicates the North Ditch is not contributing to target exceedances in Warm Springs Creek and is an insignificant source. During storm events, the contributing source area for most of the metals loading expanded to sources upstream of Galen Road (WS-3). Sources within the Anaconda vicinity that are upstream of WS-3 and have been remediated to varying degrees include the heap roast slag piles, Red Sands, and Arbiter Plant (**Table 7-2** and **Figure A-33**). Dissolved metals fractions, which are often related to ground water inputs, varied little seasonally and were typically the greatest at WS-3 and then were fairly static or decreased downstream as total metals loads increased. These trends indicate that metals loading to lower Warm Springs Creek is primarily associated with particulate metals fractions and pathways likely include overland flow that transports sediment and historical mining wastes, re-suspension of bed sediments, and/or erosion of bank material containing historical mining wastes.

No storm water data are currently available for Anaconda, but once the data are available, it is recommended that the data be reviewed to assess the magnitude of metals loading occurring via the municipal storm water system.

Loading from AFFCO within the Watershed Context

Loading from AFFCO, the only permittee with metals limits within the Upper Clark Fork TPA, was also assessed. Measurable discharge has only occurred once on site [during operating hours] since 2006, and the sample had elevated concentrations of all analyzed metals (i.e. arsenic, copper, lead, and zinc). Based on the discharge estimate, the measured metals load within runoff from AFFCO during the storm event in 2007 was compared to the load for Warm Springs Creek at the Anaconda gage using measured flow and hardness values during the same time frame and assuming Warm Springs Creek was attaining water quality targets. Loading from AFFCO was very minimal, with the greatest contribution coming from copper and lead at almost two percent of the load (**Table 7-60**).

Table 7-60. The relative load contributed by AFFCO to Warm Springs Creek during a 2007 precipitation event.

Metal	Percent of load from AFFCO
Arsenic	0.20%
Copper	1.84%
Lead	1.94%
Zinc	0.31%

TMDLs and Allocations

Based on the source assessment in **Section 7.4.4.14**, there are two permitted point sources within the Warm Springs Creek watershed. No WLA is necessary for the Washoe Park Fish Hatchery, which has no metals requirements associated with its permit (MPDES # MTG130013) and is not assumed to be a source of metals to Warm Springs Creek. Although the estimated load contribution to Warm Springs Creek from AFFCO (MPDES # MTR000068) during storm event runoff is small, it is a metals point source and is provided a WLA ($\mathbf{WLA_{AFFCO}}$). The details of the WLA calculation are discussed in the $\mathbf{WLA_{AFFCO}}$ subsection. The source assessment indicates that metals loading to lower Warm Springs Creek is associated with atmospheric deposition from the Anaconda Smelter and other diffuse historical mining sources. Therefore, a composite load allocation will be provided to historic mining sources and wastes ($\mathbf{LA_{WarmSprings}}$). Storm water from Anaconda is a diffuse source that is also addressed by the $\mathbf{LA_{WarmSprings}}$. Note, because of the presence of abandoned mines in the watershed, the source assessment should be refined as discussed in **Section 10.0** and if additional monitoring indicates discrete abandoned mining sources are also contributing to metals impairment in Warm Springs Creek, additional WLAs may be necessary in the future via adaptive management. The $\mathbf{LA_{WarmSprings}}$ is calculated by subtracting the sum of the $\mathbf{WLA_{AFFCO}}$ and load allocation to naturally occurring sources ($\mathbf{LA_{WarmSpringsNat}}$) from the TMDL. The $\mathbf{LA_{WarmSpringsNat}}$ is based on data from site WSA-1 in the upper watershed (**Figure A-32**), and although some abandoned mines are present upstream of WSA-1, measured in-stream values were well below water quality targets during high and low flow and are assumed to represent the naturally occurring condition. Background metals concentrations at WSA-1 during high and low flow were less than the detection limit for all constituents except iron (e.g. As = 3µg/L, Cd = 0.08µgL, Cu = 1µg/L, Pb = 0.5µg/L, Zn = 10µg/L), but the detection limit is used to calculate the $\mathbf{LA_{WarmSpringsNat}}$ because the actual concentration is unknown and using a concentration at the detection limit to estimate naturally occurring lead loads incorporates an implicit MOS. Also, as part of the implicit MOS, the highest measured background iron concentration (130µg/L) will be used to calculate the LA for iron. Additional considerations for the implicit MOS are discussed in **Section 7.7.2.** The TMDL components are summarized and examples are provided at the end of this section.

$\mathbf{WLA_{AFFCO}}$ Calculation

The permit for AFFCO is a storm water permit, and thus, does not have a regular discharge. In order to provide the WLA for AFFCO, the SCS curve number (CN) methodology (SCS, 1972) was used to relate precipitation events to runoff. Because infiltration capacity varies as a function of landcover condition and soil type, the CN equation presents a way to relate precipitation to rainfall excess or runoff. Necessary model parameters were derived from information in the site permit, and a composite curve number of 70 was used in the analysis based on the various landcover types at the site (e.g.roof, gravel, and grass/rangeland) and hydrologic B soil (which was verified in STATSGO). No efforts were made to validate any of the information presented in the permit file.

Based on application of the CN procedure, site runoff does not occur until 0.86 inches of precipitation is received. During a precipitation event of 1.04 inches in 2007 (according to Anaconda climate station data), discharge was estimated at AFFCO as 0.02cfs, which corresponds well to the estimated precipitation-runoff relationship at the site. As shown in **Table 7-60**, site runoff was determined for precipitation depth intervals ranging from 0.86-3 inches. For intermediate values, the equation of the line can be used by as follows to determine the runoff volume:

Runoff volume (cfs) = -0.0167x3 + 0.1856x2 – 0.272x + 0.1068
x = Precipitation (inches)

Table 7-61. Estimated AFFCO site runoff for precipitation up to 3 inches

Precipitation (in)	**Runoff Volume (cfs)**
0.86	0
1.00	0.003
1.25	0.024
1.50	0.060
1.75	0.110
2.00	0.172
2.25	0.244
2.50	0.325
2.75	0.414
3.00	0.510

Precipitation-runoff estimates for this WLA assume that no run-on from upgradient contributing areas occurs (due to the fact that detention basins and vegetated ditches contain upgradient run-on and promote direct run-on infiltration), and also do not account for rain-on-snow or other precipitation events which may increase water availability.

The target concentrations used for the WLA (**Table 7-61**) are the parameter benchmark values provided in the General Industrial Storm water permit (MTR000000) and correspond to the acute aquatic life standards, which should ensure the acute standards are not exceeded within the mixing zone during discharge. Because arsenic has a human health standard lower than the aquatic life standards, the benchmark value for arsenic corresponds to the chronic aquatic life standard.

Table 7-62. Target concentrations for the WLA for AFFCO

Metal	**Target Concentration (µg/L)**
Arsenic	150
Cadmium	2.1
Copper	14
Iron	1000
Lead	82
Zinc	120

As shown below, computed site runoff volumes were multiplied by the target concentration for each metal to calculate the WLA.

WLA$_{\textbf{AFFCO}}$ = Target Concentration (µg/L) * Runoff Volume (cfs)

Therefore, because runoff should not be generated from the site until 0.86 inches of precipitation, the **WLA**$_{\textbf{AFFCO}}$ = 0 until precipitation equals 0.86 inches or more. As an example, **Table 7-63** contains the WLA for each metal for a precipitation event of 1.25 inches. **Table 7-63** also shows the percent of the TMDL comprised by **WLA**$_{\textbf{AFFCO}}$ (using the same values to calculate the TMDL as **Table 7-60**), which emphasizes how small storm event loading from AFFCO will be to Warm Springs Creek if the WLA is met. The WLA for different precipitation events can be calculated by multiplying the runoff volumes from **Table 7-61** by the water quality target concentrations in **Table 7-62**. **Figure 7-9** illustrates the copper WLA for varying precipitation events.

Table 7-63. The WLA for each metal during a precipitation event of 1.25 inches

Metal	**Target Concentration (µg/L)**	**WLAAFFCO (lbs/day)**	**Percent of TMDL if meeting WLA**
Arsenic	150	0.0194	0.12%
Cadmium	2.1	0.0003	0.08%
Copper	14	0.0018	0.02%
Iron	1000	0.1296	0.01%
Lead	82	0.0106	0.35%
Zinc	120	0.0156	0.01%

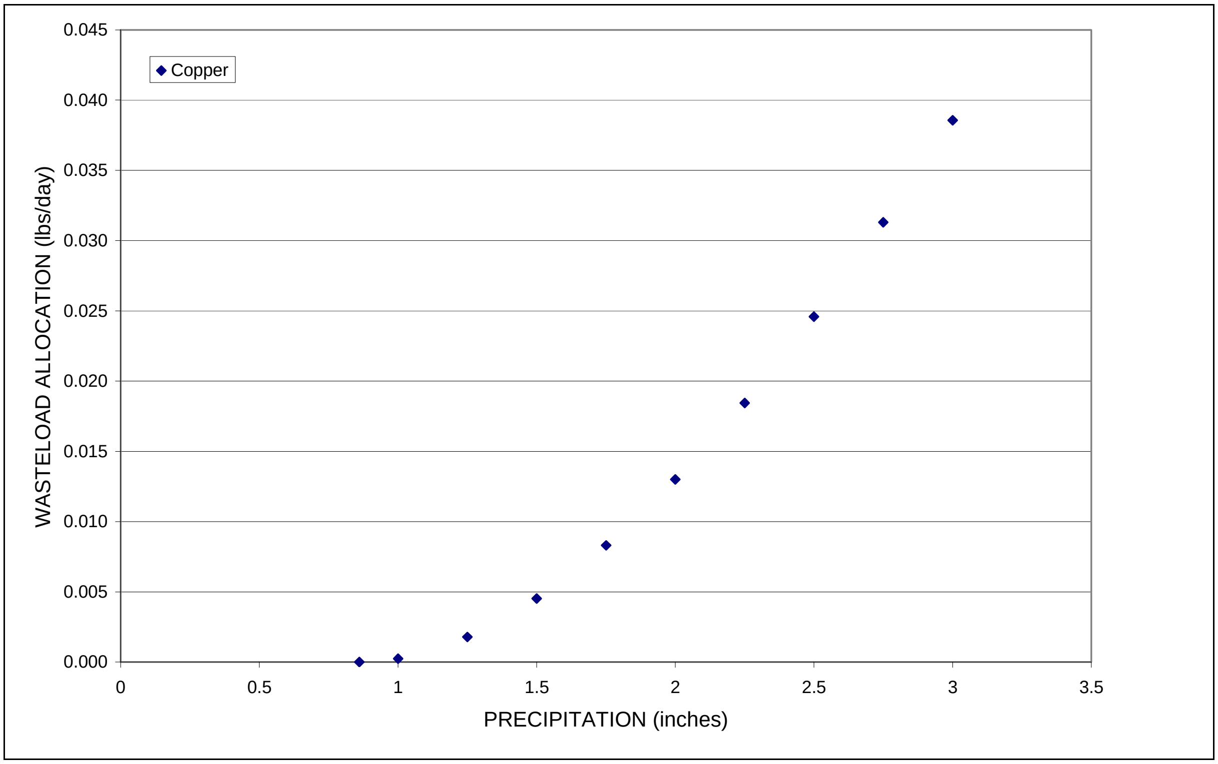


Figure 7-9. WLAAFFCO for copper with different amounts of precipitation

The WLA is provided because it is requirement for permitted point sources (of the pollutant category of concern) but is not intended to add load limits to the permit; it is assumed that the **WLA$_{AFFCO}$** will be met by adherence to the permit requirements, which include a Storm water Pollution Prevention Plan (SWPPP) with numerous BMPs. Note, the elevated metals concentrations in the recent discharge monitoring report suggests that site BMPs need to be reviewed for compliance with the permit conditions and possibly modified. However, it is a very limited amount of data and the only storm event that generated observable runoff [during operating hours] since 2006. Additionally, it is acknowledged that metals concentrations within upland soils and at the site are likely elevated because of atmospheric deposition from the Anaconda Smelter and may contribute metals loading to site runoff.

TMDL Components and Example

The TMDL components are summarized below and **Table 7-64** shows example TMDLs and allocations for measured storm event and high and low flow conditions in the Warm Springs Creek watershed. The example assumes 1.25 inches of precipitation during the storm event and no precipitation during high or low flow. This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards.

Although the Anaconda storm water system was not incorporated into the loading summary (because the data are not currently available), it is recommended that the sampling results be used to assist in prioritizing BMP implementation to meet the **LA$_{WarmSprings}$** and the TMDL.

$\mathbf{TMDL_{WarmSprings} = LA_{WarmSprings} + LA_{WarmSpringsNat} + WLA_{AFFCO}}$
$\mathbf{MOS_{WarmSprings} = Implicit}$

Table 7-64. Metals TMDLs and allocation example for the Warm Springs Creek.
“--" denotes no data available to calculate a percent reduction.

TMDLs for Warms Springs gage (high and low) and WS-6 (storm)						
Metal	**Flow Conditions**	**TMDL (lbs/day)**	**Percent Reduction Needed**	**$LA_{WarmSprings}$ (lbs/day)**	**$LA_{WarmSpringsNat}$ (lbs/day)**	**WLA_{AFFCO} (lbs/day)**
Arsenic	Storm event	2.7	34%	1.8706	0.81	0.0194
	High flow	5.076	55%	3.553	1.523	0
	Low flow	2.160	22%	1.512	0.648	0
Cadmium	Storm event	0.078	42%	0.0564	0.0216	0.0003
	High flow	0.168	20%	0.127	0.041	0
	Low flow	0.080	0%	0.063	0.017	0
Copper	Storm event	2.689	87%	2.4174	0.2700	0.0018
	High flow	5.924	89%	5.416	0.508	0
	Low flow	2.849	0%	2.633	0.216	0
Iron	Storm event	270.0000	--	234.7704	35.1000	0.1296
	High flow	507.600	41%	441.612	65.988	0
	Low flow	216.000	0%	187.920	28.080	0
Lead	Storm event	0.9480	63%	0.8021	0.1350	0.0106
	High flow	2.254	57%	2.000	0.254	0
	Low flow	1.151	0%	1.043	0.108	0
Zinc	Storm event	34.53	0%	31.8147	2.7000	0.0156
	High flow	75.957	0%	70.881	5.076	0
	Low flow	36.489	0%	34.329	2.160	0

7.6.15 Willow Creek, Upper Segment (MT76G002_061)

Loading Summary

Much of upper Willow Creek flows through the Mount Haggin Wildlife Management Area, which is an upland area with widespread effects from atmospheric deposition from the Anaconda Smelter (EPA and DEQ, 1998), and metals loading via surface runoff and ground water is apparent in the water quality data. At the Anaconda gage (near the downstream end of the segment), arsenic water quality target exceedances occurred at all flows and water quality target exceedances for the other metals of concern (i.e. cadmium, copper, iron, and lead) were concentrated during high flow periods and associated with particulates. However, arsenic, copper, and lead all had peak concentrations during low flow, which indicates a ground water component associated with loading for those metals. During low flow, most of the metals loading came from Elk Creek (near WC-5/WLW-03, **Figure A-34**) and areas downstream. During high flow, the North Fork and Elk Creek tributaries contributed most of the arsenic loading (75 percent of the arsenic load but only 38 percent of flow) but loading for other metals was typically proportional to flow contributions from different areas and increased consistently downstream.

TMDLs and Allocations

Metals loading to upper Willow Creek is associated with atmospheric deposition from the Anaconda Smelter and other diffuse historical mining sources that migrate to the creek via both surface runoff and ground water. Therefore, no WLA will be provided to the upper segment of Willow Creek. The TMDL consists of two load allocations: one composite allocation to historic mining sources and wastes ($\mathbf{LA_{UppWillow}}$) and one allocation to naturally occurring sources ($\mathbf{LA_{UppWillowNat}}$). The $\mathbf{LA_{UppWillow}}$ is calculated by subtracting $\mathbf{LA_{UppWillowNat}}$ from the TMDL. The MOS is addressed through implicit considerations (see **Section 7.7.2**).

Since smelter fallout has affected water quality throughout the upper watershed, the load allocation to naturally occurring sources ($\mathbf{LA_{UppWillowNat}}$) is calculated using concentrations from site C01MILLC02, which is the background site in the adjacent Mill Creek watershed (**Figure A-27**) and assumed to represent the background condition in upper Willow Creek. Background metals concentrations at C01MILLC02 were less than the detection limit (e.g. As = 3µg/L, Cd = 0.1µgL, Cu = 1µg/L, Fe = 10 µg/L, Pb = 0.5µg/L, Zn = 10µg/L), but the detection limit is used to calculate the $\mathbf{LA_{UppWillowNat}}$ because the actual concentration is unknown and using a concentration at the detection limit to estimate naturally occurring lead loads incorporates an implicit MOS. Background concentrations were only sampled during low flow and may be higher during high flow conditions. Additional monitoring should be conducted during high flow to assess naturally occurring conditions at high flow, and the $\mathbf{LA_{UppWillowNat}}$ may need to be modified in the future via adaptive management if data indicate the background concentration differs at high flow.

The TMDL components are summarized below and **Table 7-65** shows example TMDLs and allocations for measured storm event and high and low flow conditions in the upper Willow Creek watershed. Although the TMDL is for upper Willow Creek, target exceedances are also occurring in tributaries, and implementation is expected to include addressing these sources during remediation and result in water quality target attainment in upper Willow Creek and its tributaries. It is acknowledged that even if the migration of metals to ground water which flows into Willow Creek and its tributaries is eliminated or mitigated, particularly for arsenic, it may take much longer for concentrations in the ground water to decrease. This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards. Note, as discussed in **Section 7.4.1.2**, Willow Creek is a water body where a TI waiver of the arsenic drinking water standard may occur; if a TI waiver occurs for arsenic (or other metals), it means that it is not technically feasible to remediate sources to the extent that water quality will meet the applicable water quality standard, and the TMDL will not be met. If this occurs, the relevant water quality target(s) and TMDL(s) may need to be modified via adaptive management, which is discussed in detail in **Section 7.8**.

$TMDL_{UppWillow} = LA_{UppWillow} + LA_{UppWillowNat}$
$WLA_{UppWillow}$ = NA
$MOS_{UppWillow}$ = Implicit

Table 7-65. Metals TMDLs and allocation example for upper Willow Creek.
“--" denotes no data available to calculate a percent reduction.

TMDLs at WLW-05 (high and low) and WC-13 (storm)				**Allocations**	
Metal	**Flow Conditions**	**TMDL (lbs/day)**	**Percent Reduction Needed**	**$LA_{UppWillowNat}$ (lbs/day)**	**$LA_{UppWillow}$ (lbs/day)**
Arsenic	Storm event	0.0432	86%	0.013	0.030
	High flow	5.292	58%	1.588	3.704
	Low flow	0.069	29%	0.021	0.048
Cadmium	Storm event	0.0006	63%	0.0004	0.0002
	High flow	0.058	0%	0.0529	0.0053
	Low flow	0.001	0%	0.0007	0.0003
Copper	Storm event	0.02	87%	0.004	0.016
	High flow	1.815	76%	0.529	1.286
	Low flow	0.029	0%	0.007	0.022
Iron	Storm event	4.32	--	0.043	4.277
	High flow	529.200	51%	5.292	523.908
	Low flow	6.858	0%	0.069	6.789
Lead	Storm event	0.005	82%	0.002	0.003
	High flow	0.381	90%	0.265	0.116
	Low flow	0.0068	0%	0.0034	0.0034
Zinc	Storm event	0.258	16%	0.043	0.215
	High flow	23.507	0%	5.292	18.215
	Low flow	0.378	0%	0.069	0.309

7.6.16 Willow Creek, Lower Segment (MT76G002_062)

Loading Summary

Because of metals loading from the upper segment and lower hardness values upstream of Highway 1, many water quality target exceedances during low flow occurred in the upper portion of the segment. However, other sources of metals loading, particularly for arsenic, contributed to water quality exceedances throughout the lower segment of Willow Creek. Different trends were observed during summer and spring low flow sampling. During summer low flow sampling, most increases in metals loads corresponded to flow inputs. During spring low flow sampling in April 2007, flow increased very little over the segment, but there were significant arsenic inputs from the Willow Glen and South Fork Willow Creek watersheds. From upstream of the South Fork to downstream of Willow Glen Creek, flow increased by 45 percent but arsenic loading increased by 276 percent. For other metals, the only water quality target exceedances occurred in the South Fork, but it contributed a minimal amount of loading because flow was less than 0.1cfs.

Although loading trends during low flow indicate some ground water inputs, most effects of loading from ground water and surface sources were observed during high flow. Concentrations of all metals were greatest during high flow and storm events. Arsenic was predominately dissolved, which typically indicates a ground water sources, whereas other metals were largely particulate fractions, which is generally indicative of erosion of overland sources or re-suspension of in-channel sources. During storm events, limited flow data were collected (which would allow load calculations), but concentrations were much greater at the upper end of the reach than near the mouth, suggesting most storm-event loading is associated with sources in the upper watershed. During high flow, effects of smelter fallout within the upper segment of Willow Creek contributed to metals loads that were similar in magnitude at the upper end of the segment as at the mouth, but a closer examination of the loads at sites throughout the lower segment indicates some trends. Loads sharply declined in the upper portion of the segment and then increased between Crackerville Road and Opportunity (**Figure A-34**) by a much greater amount than flow inputs. Within that reach, flow increased at the DEQ sites by 185 percent, but arsenic, cadmium, copper, and lead loads increased by 600 to 800 percent. High flow sampling in 2007 focused on loading sources between Crackerville Road and Opportunity, and the South Fork Willow Creek and Willow Glen watersheds were identified as the dominant areas of metals loading. Loading from the South Fork watershed is likely associated with railroad-owned ponds that contain elevated metals. Arsenic loading from the Willow Glen watershed was attributed to the flushing of shallow ground water in irrigated portions of the lower watershed (personal comm. C. Coover, 2009). Other identified sources of loading include historical loading from Yellow Ditch, streamside tailings north of Highway 1 (which are scheduled for removal, **Table 7-2**), and several tile drains near the town of Opportunity. The old railroad grade near WC-13 has also been identified during the Superfund RI as a potential source of metals; the sampling sites in 2001 somewhat bracketed the area, and metals loads increased within that sampling reach, indicating it may be a source, however, the dataset is limited and additional monitoring is recommended.

TMDLs and Allocations

Metals loading to lower Willow Creek is associated with atmospheric deposition from the Anaconda Smelter and other diffuse historical mining sources. Therefore, no WLA is provided. The TMDL consists of two load allocations: one composite allocation to historic mining sources and wastes (**LA_{Willow}**) and one allocation to naturally occurring sources (**$LA_{WillowNat}$**). The **LA_{Willow}** is calculated by subtracting **$LA_{WillowNat}$** from the TMDL. The MOS is addressed through implicit considerations (see **Section 7.7.2**). Note, because of the presence of historic mining wastes, the source assessment should be refined as discussed in **Section 10.0** and if additional monitoring indicates discrete areas of mining wastes that are contributing to metals impairment in Willow Creek, WLAs may be necessary in the future via adaptive management.

Since smelter fallout has affected water quality throughout the watershed, the load allocation to naturally occurring conditions (**$LA_{WillowNat}$**) is calculated using concentrations from site C01MILLC02, which is the background site in the adjacent Mill Creek watershed (**Figure A-27**) and assumed to represent the background condition in Willow Creek. Background metals concentrations at C01MILLC02 were less than the detection limit (e.g. As = 3µg/L, Cd = 0.1µgL, Cu = 1µg/L, Fe = 10 µg/L, Pb = 0.5µg/L, Zn = 10µg/L), but the detection limit is used to calculate the $\mathbf{LA_{WillowNat}}$ because the actual concentration is unknown and using a concentration at the detection limit to estimate naturally occurring lead loads incorporates an implicit MOS. Background concentrations were only sampled during low flow and may be higher during high flow conditions. Additional monitoring should be conducted during high flow to assess naturally occurring conditions at high flow, and the $\mathbf{LA_{WillowNat}}$ may need to be modified in the future via adaptive management if data indicate the background concentration differs at high flow.

The TMDL components are summarized below and **Table 7-66** shows example TMDLs and allocations for measured storm event and high and low flow conditions in the lower Willow Creek watershed. Although the TMDL is for lower Willow Creek, target exceedances are also occurring in tributaries, and implementation is expected to include addressing these sources during remediation and result in water quality target attainment in Willow Creek and its tributaries. It is acknowledged that even if the migration of metals to ground water which flows into Willow Creek and its tributaries is eliminated or mitigated, particularly for arsenic, it may take much longer for concentrations in the ground water to decrease. This allocation scheme assumes that natural loading rates do not cause water quality standards to be exceeded and applying BMPs to the human-caused metals sources will result in the loading reductions necessary to meet the TMDLs and water quality standards. Note, as discussed in **Section 7.4.1.2**, Willow Creek is a water body where a TI waiver of the arsenic drinking water standard may occur; if a TI waiver occurs for arsenic (or other metals), it means that it is not technically feasible to remediate sources to the extent that water quality will meet the applicable water quality standard, and the TMDL will not be met. If this occurs, the relevant water quality target(s) and TMDL(s) may need to be modified via adaptive management, which is discussed in detail in **Section 7.8**.

$\mathbf{TMDL_{Willow} = LA_{Willow} + LA_{WillowNat}}$
$\mathbf{WLA_{Willow} = NA}$
$\mathbf{MOS_{Willow} = Implicit}$

Table 7-66. Metals TMDLs and allocation example for lower Willow Creek.
“--" denotes no data available to calculate a percent reduction.

TMDLs at WLW-11 (high and low) and WC-15 (storm)				**Allocations**	
Metal	**Flow Conditions**	**TMDL (lbs/day)**	**Percent Reduction Needed**	$\mathbf{LA_{WillowNat}}$ **(lbs/day)**	$\mathbf{LA_{Willow}}$ **(lbs/day)**
Arsenic	Storm event	0.556	66%	0.167	0.389
	High flow	4.007	87%	1.202	2.805
	Low flow	0.316	23%	0.095	0.221
Cadmium	Storm event	0.018	0%	0.006	0.012
	High flow	0.096	8%	0.040	0.056
	Low flow	0.011	0%	0.003	0.008

Table 7-66. Metals TMDLs and allocation example for lower Willow Creek.
“--" denotes no data available to calculate a percent reduction.

TMDLs at WLW-11 (high and low) and WC-15 (storm)				Allocations	
Metal	**Flow Conditions**	**TMDL (lbs/day)**	**Percent Reduction Needed**	**$LA_{WillowNat}$ (lbs/day)**	**LA_{Willow} (lbs/day)**
Copper	Storm event	0.641	40%	0.056	0.585
	High flow	3.190	74%	0.401	2.789
	Low flow	0.398	0%	0.032	0.366
Iron	Storm event	55.620	--	0.556	55.064
	High flow	400.734	0%	4.007	396.727
	Low flow	31.590	0%	0.316	31.274
Lead	Storm event	0.243	52%	0.028	0.215
	High flow	1.006	69%	0.200	0.805
	Low flow	0.157	0%	0.016	0.141
Zinc	Storm event	8.215	0%	0.556	7.658
	High flow	41.003	0%	4.007	36.996
	Low flow	5.095	0%	0.316	4.779

7.7 Seasonality and Margin of Safety

All TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety into the load allocation process to account for uncertainties in pollutant sources and other watershed conditions, and ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes the considerations of seasonality and a margin of safety in the Upper Clark Fork TPA metal TMDL development process.

7.7.1 Seasonality

Seasonality addresses the need to ensure year round beneficial use support. Seasonality was considered for assessing loading conditions and for developing water quality targets, TMDLs, and allocation schemes. For metals TMDLs, seasonality is critical due to varying metals loading pathways and varying water hardness during high and low flow conditions. Loading pathways associated with overland flow and erosion of metals-contaminated soils and wastes tend to be the major cause of elevated metals concentrations during high flows, with the highest concentrations and metals loading typically occurring during the rising limb of the hydrograph. Loading pathways associated with ground water transport and/or adit discharges tend to be the major cause of elevated metals concentrations during low or base flow conditions. Hardness tends to be lower during higher flow conditions, thus leading to lower water quality standards for some metals during the runoff season. Seasonality is addressed in this document as follows:

- Metals concentrations and loading conditions are evaluated for both high flow and low flow conditions. Storm event data were also incorporated where available.

- Metals TMDLs incorporate stream flow as part of the TMDL equation.
- Metals targets apply year round, with monitoring criteria for target attainment developed to address seasonal water quality extremes associated with loading and hardness variations.
- Example targets, TMDLs and load reduction needs are developed for high and low flow conditions (and storm events in some cases).

7.7.2 Margin of Safety

The margin of safety is to ensure that TMDLs and allocations are sufficient to sustain conditions that will support beneficial uses. All metals TMDLs incorporate an implicit MOS in several ways. The implicit margin of safety is applied by using conservative assumptions throughout the TMDL development process and is addressed by the following:

- Target attainment, refinement of load allocations, and, in some cases, impairment validations and TMDL-development decisions are all based on an adaptive management approach that relies on future monitoring and assessment for updating planning and implementation efforts.
- Chronic standards were used to calculate a daily load limit rather than a 96-hour load limit
- Sediment metals concentration criteria were used as secondary indicators.
- Where background concentrations upstream of mining sources were available and below the detection limit for a metal, a conservative approach to calculating the LA to background sources was taken by using a concentration at the detection limit. If concentrations were above the detection limit, the highest measured background concentration was used for each metal of concern.

7.8 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, applicable target values, source assessments, loading calculations, modeling assumptions, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. While uncertainties are an undeniable fact of TMDL development, mitigation and reduction of uncertainties through adaptive management approaches is a key component of ongoing TMDL implementation and evaluation. Uncertainties, assumptions, and considerations are addressed throughout this document and point to the need to refine analysis, conduct further monitoring, and address unknowns in order to develop better understanding of impairment conditions and the processes that affect impairment. This process of adaptive management is predicated on the premise that targets, TMDLs, allocations, and the analyses supporting them are not static, but are processes subject to modification and adjustment as new information and relationships are understood.

The adaptive management process allows for continual feedback on the progress of restoration activities and status of beneficial uses. It provides the flexibility to refine targets as necessary to ensure protection of the resource or to adapt to new information concerning target achievability. For instance, as a result of additional monitoring and source refinement discussed in the **Section 10.0**, additional WLAs may be necessary for abandoned mines that are found to be discrete sources and the allocations and margin of safety may be modified. Components may be changed to improve ways of achieving and measuring success. A restoration and monitoring plan is closely linked to the adaptive management process and is described in detail in **Sections 9.0** and **10.0**.

The water quality restoration targets and associated metals TMDLs developed for the Upper Clark Fork TPA are based on future attainment of the B-1 classification water quality standards. In order to achieve attainment, all significant sources of metal loading must be addressed via all reasonable land, soil, and water conservation practices. It is recognized however, that in spite of all reasonable efforts, attainment of restoration targets may not be possible due to the potential presence of unalterable human-caused sources and/or natural background sources of metals loading. For this reason, an adaptive management approach is adopted for all metals targets described within this document. Under this adaptive management approach, all metals identified in this plan as requiring TMDLs will ultimately fall into one of the three categories identified below:

- Implementation of restoration activities resulting in full attainment of restoration targets for all parameters;
- Implementation of restoration activities fails to result in target attainment due to underperformance or ineffectiveness of restoration actions. Under this scenario the water body remains impaired and will require further restoration efforts associated with the pollutants of concern. The target may or may not be modified based on additional information, but conditions still exist that require additional pollutant load reductions to support beneficial uses and meet applicable water quality standards. This scenario would require some form of additional, refocused restoration work.
- Implementation of restoration activities fails to result in target attainment, but target attainment is deemed unachievable even though all applicable monitoring and restoration activities have been completed. A TI waiver falls under this category. Under this scenario, site-specific water quality standards and/or the reclassification of the water body may be necessary. This would then lead to a new target (and TMDL) for the pollutant(s) of concern, and the new target could either reflect the existing conditions at the time or the anticipated future conditions associated with the restoration work that has been performed.

The DEQ Remediation Division and/or DEQ Standards Program personnel will lead this effort within DEQ to make determinations concerning the appropriateness of specific mine cleanup activities relative to expectations for mining cleanup efforts for any impairment condition associated with mining impacts. This includes consideration of appropriate evaluation of cleanup options, actual cleanup planning and design, as well as the appropriate performance and maintenance of the cleanup activities. Where NPDES permitted point sources are involved, the DEQ Permitting Program will also be involved. Determinations on the performance of all aspects of restoration activities, or lack thereof, will then be used along with available in-stream data to evaluate the appropriateness of any given target and beneficial use support. Reclamation activities and monitoring conducted by other parties, including but not limited to the USFS and BLM, should be incorporated into the process as well. The information will also help determine any further cleanup/load reduction needs for any applicable water body and will ultimately help determine the success of water quality restoration.

It is acknowledged that construction or maintenance activities related to restoration, construction/maintenance, and future development may result in short term increase in surface water metals concentrations. For any activities that occur within the stream or floodplain, all appropriate permits should be obtained before commencement of the activity. Federal and State permits necessary to conduct work within a stream or stream corridor are intended to protect the resource and reduce, if not completely eliminate, pollutant loading or degradation from the permitted activity. The permit requirements typically have mechanisms that allow for some short term impacts to the resource, as long as all appropriate measures are taken to reduce impact to the least amount possible.

SECTION 8
OTHER PROBLEMS/CONCERNS

8.1 Pollution Listings

Water quality issues are not limited simply to those streams where TMDLs are developed. In some cases, streams have not yet been reviewed through the assessment process and do not appear on the 303(d) List (such as Browns Gulch or Cottonwood Creek). In other cases, streams in the Upper Clark Fork TPA may appear on the 303(d) List but may not always require TMDL development for a pollutant, but do have pollution listings such as "alteration in stream-side or littoral vegetation covers" that could be linked to a pollutant. These habitat related pollution causes are often associated with sediment issues, or potential sediment issues, or may be having a deleterious effect on a beneficial use without a clearly defined quantitative measurement or direct linkage to a pollutant to describe that impact. Nevertheless, the issues associated with these streams are still important to consider when attempting to improve water quality conditions in individual streams, and the Clark Fork watershed as a whole. In some cases, pollutant and *pollution* causes are listed for water body, and the management strategies as incorporated through the TMDL development for the pollutant, inherently address some or all of the pollution listings. **Table 8-1** presents the *pollution* listings in the Upper Clark Fork, and highlights those streams listed that do not have any associated pollutant listings.

Table 8-1. Water body segments in the Upper Clark Fork TPA with pollution listings related to the 2008 303(d) List pollutants of concern addressed in this document

Water Body ID	Stream Segment	2008 Probable Causes of Impairment
MT76G002_140	**ANTELOPE CREEK*,** headwaters to the mouth (Gardner Ditch)	*Low flow alterations*
MT76G002_030	**CABLE CREEK**, headwaters to the mouth (Warm Springs Creek)	*Other anthropogenic substrate alterations, Physical substrate habitat alterations*
MT76G002_100	**DEMPSEY CREEK**, the national forest boundary to mouth (Clark Fork River)	*Alteration in stream-side or littoral vegetative covers, low flow alterations*
MT76G005_071	**DUNKLEBERG CREEK***, headwaters to SW corner Sec 2, T9N, R12W	*Alterations in stream-side or littoral vegetative covers*
MT76G005_072	**DUNKLEBERG CREEK***, SW corner Sec 2, T9N, R12W to mouth (Clark Fork River)	*Alterations in stream-side or littoral vegetative covers*
MT76G005_091	**GOLD CREEK*,** headwaters to the Natl. Forest boundary	*Alterations in stream-side or littoral vegetative covers*
MT76G005_092	**GOLD CREEK*,** the forest boundary to the mouth (Clark Fork River)	*Low flow alterations*
MT76G005_082	**HOOVER CREEK***, Miller Lake to the mouth (Clark Fork River)	*Physical substrate habitat alterations, Low flow alterations*
MT76G002_072	**LOST CREEK*,** the south State Park boundary to the mouth (Clark Fork River)	*Low flow alterations, Alteration in stream-side or littoral vegetation covers, low flow alterations*
MT76G002_052	**MILL CREEK*,** section line between Sec 27 & 28, T4N, R11W to the mouth (Silver Bow Creek)	*Alteration in stream-side or littoral vegetative covers, low flow alterations*

Table 8-1. Water body segments in the Upper Clark Fork TPA with pollution listings related to the 2008 303(d) List pollutants of concern addressed in this document

Water Body ID	Stream Segment	2008 Probable Causes of Impairment
MT76G002_080	**MODESTY CREEK*,** headwaters to the mouth (Clark Fork River)	*Low flow alterations*
MT76G002_131	**PETERSON CREEK**, headwaters to Jack Creek	*Alteration in stream-side or littoral vegetative covers, Low flow alterations*
MT76G002_132	**PETERSON CREEK*,** Jack Creek to the mouth (Clark Fork River)	*Alteration in stream-side or littoral vegetative covers, physical substrate habitat alterations, Low flow alterations*
MT76G002_090	**RACETRACK CREEK*,** the national forest boundary to the mouth (Clark Fork River)	*Alterations in stream-side or littoral vegetation covers, Low flow alterations*
MT76G002_040	**STORM LAKE CREEK**, headwaters to the mouth (Warm Springs Creek)	*Alteration in stream-side or littoral vegetative covers, Low flow alterations*
MT76G005_110	**TIN CUP JOE CREEK***, Tin Cup Lake to the mouth (Clark Fork River)	*Low flow alterations*
MT76G005_111	**WARM SPRINGS CREEK**, (near Phosphate), headwaters to line between R9W and R10W	*Alteration in stream-side or littoral vegetative covers*
MT76G005_112	**WARM SPRINGS CREEK**, (near Phosphate), from line between R9W and R10W to mouth (Clark Fork River)	*Alteration in stream-side or littoral vegetative covers, Physical substrate habitat alterations, Low flow alterations*
MT76G002_061	**WILLOW CREEK**, Headwaters to T4N, R10W, Sec 30 (DABC)	*Alteration in stream-side or littoral vegetative covers*
MT76G002_062	**WILLOW CREEK***, T4N, R10W, Sec 30 (DABC) to the mouth (Silver Bow Creek)	*Alteration in stream-side or littoral vegetative covers, Low flow alterations*

* Streams listed for *pollution*, and have no associated sediment or temperature pollutant listings.

8.2 Pollution Causes of Impairment Descriptions

Pollution listings are often used as a probable cause of impairment when available data at the time of assessment does not necessarily provide a direct quantifiable linkage to a specific pollutant, however non-pollutant sources or indicators do indicate impairment. In some cases the pollutant and pollution categories are linked and appear together in the cause listings, however a pollution category may appear independent of a pollutant listing. The following discussion provides some rationale for the application of a pollution cause to a water body, and thereby provides additional insight into possible factors in need of additional investigation or remediation.

Alteratation in Stream-side or Littoral Vegetation Covers

Alteration in stream-side or littoral vegetation covers refers to circumstances where practices along the stream channel have altered or removed riparian vegetation and subsequently affected channel geomorphology and/or stream temperature. Such instances may be riparian vegetation removal for a road or utility corridor, or overgrazing by livestock along the stream. As a result of altering the stream-side vegetation, destabilized banks from loss of vegetative root mass could lead to over-widened stream channel conditions, and the resultant lack of canopy cover can lead to increased water temperatures.

Other Anthropogenic Substrate Alterations

Streams may be listed for other anthropogenic substrate alterations when data indicates impacts to the stream channel have resulted from apparent anthropogenic activities, but parameters related to substrate (pebble counts) do not appear high, and morphological characteristics such as width/depth or entrenchment are also within expected values. For example, this would take place in a system where the reduction or historic reduction of vegetation capable of producing large woody debris has occurred, in a system where large woody debris is integral to pool development (quality and quantity) and channel function.

Physical Substrate Habitat Alterations

Physical substrate habitat alterations generally describe cases where the stream channel has been physically altered or manipulated, such as through the straightening of the channel or from anthropogenically influenced channel downcutting, resulting in a reduction of morphological complexity and loss of habitat (riffles and pools) for fish and aquatic life. For example, this may occur when a stream channel has been straightened to accommodate roads, agricultural fields, or through placer mine operations.

Low Flow Alterations

Streams are typically listed for low flow alterations when irrigation withdrawal management leads to base flows that are too low to support the beneficial uses designated for that system. This could result in dry channels or extreme low flow conditions unsupportive of fish and aquatic life. It could also result in lower flow conditions which absorb thermal radiation more readily and increase stream temperatures, which in turn creates dissolved oxygen conditions too low to support some species of fish.

It should be noted that while Montana law states that TMDLs cannot impact Montana water rights and thereby affect the allowable flows at various times of the year, the identification of low flow alterations as a probable source of impairment does not violate any state or federal regulations or guidance related to stream assessment and beneficial use determination. Subsequent to the identification of this as a probable cause of impairment, it is up to local users, agencies, and entities to improve flows through water and land management.

8.3 Monitoring and BMPs for Pollution Affected Streams

Streams listed for *pollution* as opposed to a pollutant should not be overlooked when developing watershed management plans. Attempts should be made to collect sediment and temperature information where data is minimal and the linkage between probable cause, pollution listing, and affects to the beneficial uses are not well defined. The monitoring and restoration strategies that follow in **Sections 9** and **10** are presented to address pollutant and issues for Upper Clark Fork tributaries, are equally applicable to streams listed for the above pollution categories.

SECTION 9.0
FRAMEWORK WATER QUALITY RESTORATION STRATEGY

9.1 Summary of Restoration Strategy

This section provides a framework strategy for water quality restoration in the upper Clark Fork watershed, focusing on how to meet conditions that will likely achieve the TMDLs presented in this document. This section identifies which activities will contribute the most reduction in pollutants for each TMDL. Limited information about spatial application of each restoration activity will be provided.

This section should assist stakeholders in developing a more detailed adaptive Watershed Restoration Plan (WRP) in the future. The locally-developed WRP will likely provide more detailed information about restoration goals and spatial considerations within the watershed. The WRP may also encompass broader goals than the focused water quality restoration strategy outlined in this document. The intent of the WRP is to serve as a locally organized “road map” for watershed activities, sequences of projects, prioritizing types of projects, and funding sources towards achieving local watershed goals, including water quality improvements. Within this plan, the local stakeholders would identify and prioritize streams, tasks, resources, and schedules for applying Best Management Practices (BMPs). As restoration experiences and results are assessed through watershed monitoring, this strategy could be adapted and revised by stakeholders based on new information and ongoing improvements.

9.2 Role of DEQ, Other Agencies, and Stakeholders

The DEQ does not implement TMDL pollutant reduction projects for nonpoint source activities, but can provide technical and financial assistance for stakeholders interested in improving their water quality. The DEQ will work with participants to use the TMDLs as a basis for developing locally-driven WRPs, administer funding specifically to help fund water quality improvement and pollution prevention projects, and can help identify other sources of funding.

Because most nonpoint source reductions rely on voluntary measures, it is important that local landowners, watershed organizations, and resource managers continue to work collaboratively with local and state agencies to achieve water quality restoration which will progress toward meeting water TMDL targets and load reductions. Specific stakeholders and agencies that have been, and will likely continue to be, vital to restoration efforts include the Watershed Restoration Coalition of the Upper Clark Fork (WRC), Clark Fork Coalition, Deer Lodge Conservation District, USFS, NRCS, DNRC, FWP, NRDP, EPA and DEQ. Other organizations and non-profits that may provide assistance through technical expertise, funding, educational outreach, or other means include Montana Water Trust, Montana Water Center, University of Montana Watershed Health Clinic, and MSU Extension Water Quality Program.

9.3 Watershed Restoration Goals

The following are general water quality goals provided in this TMDL document:

- Provide technical guidance for full recovery of aquatic life beneficial uses to all impaired streams within the Upper Clark Fork TPA by improving sediment, metal, and temperature water quality conditions. This technical guidance is provided by the TMDL components in the document which include:
    - water quality targets,
    - pollutant source assessments, and
    - general restoration guidance which should meet the TMDL allocations.
- Assess watershed restoration activities to address significant pollutant sources.

A WRP is a locally-derived plan that can be more dynamic than the TMDL document. It can be refined as activities progress and address more broad goals than those included in this TMDL document. The following elements may be included in a stakeholder-derived WRP in the near future:

- Support for implementing restoration projects to protect water conditions so that all streams in the watershed maintain good water quality with an emphasis on waters with TMDLs completed.
- More detailed cost/benefit analysis and spatial considerations for water quality improvement projects.
- Develop an approach for future BMP installment and efficiency results tracking.
- Provide information and education components to assist with stakeholder outreach about restoration approaches, benefits and funding assistance.
- Other various watershed health goals.
- Weed control initiatives
- Other local watershed based issues.

Specific water quality goals (i.e. targets) for each pollutant are detailed in the section pertaining to each pollutant (**Sections 5-7).** These targets serve as the basis for long-term effectiveness monitoring for achieving the above water quality goals. These targets specify satisfactory conditions to ensure protection and/or recovery of beneficial uses of water bodies in the Upper Clark Fork TPA. **Section 10** identifies a general monitoring strategy and recommendations designed to track implementation water quality conditions and restoration successes.

9.4 Overview of Management Recommendations

Sediment TMDLs were completed for 13 water body segments. Temperature TMDLs were completed for Peterson Creek. TMDLs were completed for a variety of metals on 17 water body segments. Other streams in the watershed may be in need of TMDLs, but insufficient information about them precludes TMDL formation at this time. In general, sediment, thermal, and to some extent, metal loading can be greatly reduced by focusing restoration efforts on streamside riparian restoration and long term riparian zone management. Stream channel restoration may be necessary in areas that have lost channel integrity due to long term riparian vegetation impacts. Other sediment restoration actions include unpaved road erosion control near streams. Temperature TMDL attainment will depend upon improving stream shade using increased riparian vegetation, stream channel narrowing/deepening, and irrigation and stockwater conservation management. Activities that reduce sediment loading will also decrease metals loading, but abandoned mines are the most important source to target for metals restoration.

9.4.1 Sediment Restoration Approach

Streamside riparian vegetation restoration and long term riparian area management are vital restoration practices that must be implemented across the watershed to achieve the sediment TMDLs. Vigorous native streamside riparian vegetation provides root mass which hold streambanks together. Suitable root mass density ultimately slows bank erosion. Riparian vegetation filters sediment from upland runoff. Therefore, improving riparian vegetation will decrease bank erosion by improving streambank stability and will also reduce sediment delivery from upland sources. Sediment is also deposited more heavily in healthy riparian zones during flooding because water velocities slow in these areas enough for excess sediment to settle out.

The predominant cause of riparian and stream channel degradation in the Upper Clark Fork TPA comes from grazing of domesticated livestock in and near streams. Restoration recommendations involve improved grazing management, including the timing and duration of grazing, the development of multi-pasture systems that include riparian pastures, and the development of off-site watering areas. Additionally, grazing management, combined with some additional fencing costs in many riparian areas, would promote natural recovery. Active vegetation planting along with bank sloping may increase costs, but still remains within a reasonable and relatively cost effective restoration approach. When stream channel restoration work is needed because of altered stream channels, costs increase and projects should be assessed on a case by case basis. In general, these are sustainable agricultural practices that promote attainment of conservation objectives while meeting agricultural production goals. The BMPs aim to prevent availability, transport, and delivery of sediment by a combination of minimizing sediment delivery, reducing the rate of runoff, and intercepting sediment transport. The appropriate BMPs will differ by landowner and are recommended to be part of a comprehensive farm/ranch plan.

Although roads may be a small source of sediment at the watershed scale, sediment derived from roads may cause significant localized impact in some stream reaches. Restoration approaches for unpaved roads near streams should be to divert water off of roads and ditches before it enters the stream. The diverted water should be routed through natural healthy vegetation, which will act as filter zones for the sediment laden runoff before it enters streams. Sediment loads from culvert failure and culvert caused scour were not assessed by the TMDL source assessment, but should be considered in road sediment restoration approaches.

Areas that have increased erosion as a result of mining-related atmospheric deposition should be evaluated within the WRP. As the result of a 2008 Consent Decree between the State of Montana, the EPA, and the Atlantic Richfield Company (ARCO), reclamation of soils affected by the Anaconda Smelter is currently planned for 2010 on the Clark Fork side of Mt. Haggin (Greg Mullen, pers. comm., 2008). However, activities such as revegetation and limited shrub plantings, which will be used during the reclamation, are also applicable throughout the upper Clark Fork watershed. Historic placer mining activities may have very localized impacts that affect sediment production within the watershed. If found, mining caused sediment sources that can be restored at reasonable costs could be prioritized into the watershed restoration plan. Any other unknown sediment sources could also be incorporated into the watershed restoration plan while considering cost and sediment reduction benefits.

Land use improvements through best management practices and sound planning should be sought whenever possible and applies to everything from timber harvest, to residential planning, to ranch and farming operations. Assistance from resource professionals from various local, state, and federal agencies or non-profit groups is widely available in the Upper Clark Fork TPA. In particular, the local USDA Service Center and Conservation District in Deer Lodge, and the Watershed Restoration Coalition of the Upper Clark Fork are two resources that are valuable aids for assisting with investigating, developing, and implementing measures to improve conditions in the Upper Clark Fork watershed.

All of these best management practices are considered reasonable restoration approaches due to their benefit and generally low costs. Riparian restoration and road erosion control are standard best management practices identified by NRCS, and are not overly expensive to our society. Although the appropriate BMP will vary by water body and site, controllable sources and BMP types can be prioritized by watershed to reduce sediment loads in individual streams. Additional information related to the specific sediment loads and their sources within each watershed that may assist with prioritization for restoration planning is presented in **Appendix I**.

9.4.2 Metals Restoration Approach

This section outlines strategies for addressing metals loading sources in need of restoration activities within the Upper Clark Fork TPA. The restoration strategies focus on regulatory mechanisms and/or programs applicable to the controllable source types present within the watershed; which, for the most part, are associated with historic mining and mining legacy issues. Potential metals loading sources associated with abandoned mines include discharging mine adits and mine waste materials on-site and in-channel. The goal of the metals restoration plan is to limit the input of metals to stream channels from priority abandoned mine sites and other identified sources of metals impairments. For most of the mining-related sources, additional analysis will likely be required to identify site specific metals delivery pathways and to develop mitigation plans.

As indicated in **Table 7-2**, additional Superfund remediation and reclamation work is underway and/or planned within several areas of the TPA. Because Superfund/CERCLA clean-up goals do not always correspond to Montana water quality standards, additional remediation may be necessary to meet metals TMDLs. However, after all planned remediation work is complete, effectiveness and trends monitoring should be conducted to determine if additional measures are needed to meet the TMDLs and to assess if target attainment may not be achievable for all metals.

In addition to abandoned mine wastes and historic placer mining, atmospheric deposition from the Anaconda Smelter has led to increased metals loads to several streams in the planning area and should be incorporated into the WRP. Smelter fallout contributes excess metals to water bodies by the erosion of affected sediment (which in addition to elevated metals concentrations, frequently has an altered plant community because of phytotoxic effects from smelter fallout) and migration into ground water (primarily arsenic). Elevated metals concentrations within Modesty, Mill, Willow, Lost, and Warm Springs creeks have been at least partially attributed to atmospheric deposition from the Anaconda Smelter. The Mill Willow Bypass is within both the Anaconda Smelter and Butte-Silver Bow site and has likely been affected by atmospheric deposition from the Anaconda Smelter and smelters along Silver Bow Creek. German Gulch is a tributary to Silver Bow Creek and near its mouth is part of the Butte-Silver Bow Superfund Site; this portion of German Gulch may be affected by historical atmospheric deposition from smelters along Silver Bow Creek, which ceased operating around 1910 (EPA 2005). Restoration of areas with elevated soils metal concentrations and implementation of BMPs to prevent erosion of contaminated soils will reduce metals and sediment loading, but reductions in ground water metals concentrations associated with non-point sources may be much more difficult to address and may not occur for a long time.

Goals and objectives for future restoration work include the following:

- Prevent soluble metal contaminants or metals contaminated solid materials in the waste rock and tailings materials/sediments from migrating into adjacent surface waters to the extent practicable.

- Reduce or eliminate concentrated runoff and discharges that generate sediment and/or heavy metals contamination to adjacent surface waters and ground water to the extent practical.

- Identify, prioritize, and select response and restoration actions based on a comprehensive source assessment and streamlined risk analysis of areas affected by historical mining.

9.4.3 Temperature Restoration Approach

A temperature TMDL was developed for Peterson Creek by means of a temperature model which utilized water temperature, stream flow and streamside vegetation data. This effort collected streamflow measurements in Peterson Creek and associated tributaries, but was only a snapshot of flow conditions during the end of July. The approach for attainment of temperature targets is based upon reaching stream channel and streamside vegetation conditions equaling reference areas.

Another very important restoration factor for meeting temperature conditions that support instream uses depends upon irrigation and stock water management with water savings being applied to instream flow during warm summer months. Irrigation water management should not only apply to Peterson Creek, but also on tributaries throughout the upper Clark Fork watershed. Irrigation also has a large influence on ground water in the Clark Fork valley, which in turn, influences surface water conditions. Irrigation efficiency projects should consider how they could affect cool ground water return flows during the summer months prior to initiation. Local coordination and planning are especially important for future flow management activities, because State law indicates that legally obtained water rights cannot be divested, impaired, or diminished by Montana’s water quality law (MCA 75-5-705). More detailed irrigation system restoration approaches are presented in **Section 9.5.4**.

9.4.5 Pollution Restoration Approach

Although TMDL development is not required for pollution listings, they are frequently linked to pollutants, and addressing pollution sources is an important component of TMDL implementation. Pollution listings within the Upper Clark Fork TPA include alteration in stream-side or littoral vegetative covers, physical substrate habitat alterations, other anthropogenic substrate alterations, low flow alterations, and other flow regime alterations. Typically, habitat impairments are addressed during implementation of sediment, nutrient, and temperature TMDLs. Although flow alterations have the most direct link with temperature, and temperature TMDLs are the only TMDLs that explicitly discusses flow, adequate flow is also critical for transporting sediment and diluting metals inputs. Therefore, if restoration goals within the Upper Clark Fork TPA are not also addressing pollution impairments, additional pollution-related BMP implementation should be considered. Habitat and flow BMPs are discussed below in **Section 9.5**.

9.5 Restoration Approaches by Source

General management recommendations are outlined below for the major sources of human caused pollutant loads in the Upper Clark Fork TPA: grazing, cropland, riparian vegetation removal, irrigation, unpaved roads, and mining-related sources. Applying ongoing BMPs are the core of the sediment reduction strategy, but are only part of the restoration strategy. Restoration activities may also address other current pollution-causing uses and management practices. In some cases, efforts beyond implementing new BMPs may be required to address key sediment sources. In these cases, BMPs are usually identified as a first effort and an adaptive management approach will be used to determine if further restoration approaches are necessary to achieve water quality standards. Monitoring is also an important part of the restoration process. Monitoring recommendations are outlined in **Section 11.0**.

9.5.1 Grazing

Development of riparian grazing management plans is a goal for landowners in the watershed who do not currently have such plans. Private land owners may be assisted by state, county federal, and local conservation groups to establish and implement appropriate grazing management plans. Note that riparian grazing management does not necessary eliminate all grazing in these areas. Nevertheless, in some areas, a more restrictive management strategy may be necessary for a period in order to accelerate re-establishment of a riparian community with the most desirable species composition and structure.

Grazing management includes the timing and duration of grazing, the development of multi-pasture systems, including riparian pastures, and the development of off-site watering areas. The key strategy of the recommended grazing BMPs is to develop and maintain healthy riparian vegetation and minimize disturbance of the stream bank and channel. The primary recommended BMPs for the upper Clark Fork watershed are providing off-site watering sources, limiting livestock access to streams and hardening the stream at access points, planting woody vegetation along stream banks, and establishing riparian buffers. Although bank revegetation is a preferred BMP, in some instances bank stabilization may be necessary prior to planting vegetation. Other general grazing management recommendations and BMPs to address grazing sources of pollutants and pollution are listed below (**Table 9-1**). Further information on grazing BMPs can be obtained in **Appendix A** of Montana's NPS Management Plan (DEQ, 2007).

Table 9-1. General grazing/wildlife BMPs and management techniques (from NRCS 2001; DNRC 1999).

BMP and Management Techniques	Pollutants Addressed
Design a grazing management plan and determine the intensity, frequency, duration, and season of grazing to promote desirable plant communities and productivity of key forage species. In this case, native riparian vegetation.	Sediment, temperature, nutrients
Encourage the growth of woody species (willow, alder, etc.) along the streambank, which will limit animal access to the stream and provide root support to the bank.	Sediment, nutrients, temperature
Establish riparian buffer strips of sufficient width and plant composition to filter and take up nutrients and sediment from concentrated animal feeding operations.	Sediment, nutrients,
Create riparian buffer area protection grazing exclosures through fencing.	Sediment, temperature, nutrients
Maintain adequate vegetative cover to prevent accelerated soil erosion, protect streambanks, and filter sediments. Set target grazing use levels to maintain both herbaceous and woody plants.	Sediment
Ensure adequate residual vegetative cover and regrowth and rest periods. Periodically rest or defer riparian pastures during the critical growth period of plant species.	Sediment, nutrients
Distribute livestock to promote dispersion and decomposition of manure and to prevent the delivery of manure to water sources.	Nutrients
Alternate a location's season of use from year to year. Early spring use can cause trampling and compaction damage when soils and streambanks are wet. If possible, develop riparian pastures to be managed as a separate unit through fencing.	Nutrients, sediment
Provide off-site, high quality water sources.	Nutrients, sediment
Periodically rotate feed and mineral sites and generally keep them in uplands.	Nutrients, sediment
Place salt and minerals in uplands, away from water sources (ideally ¼ mile from water to encourage upland grazing).	Sediment, nutrients, temperature
Monitor livestock forage use and adjust strategy accordingly.	Sediment, nutrients, temperature
Create hardened stream crossings.	Sediment

9.5.2 Animal Feeding Operations

Animal feeding operations (AFOs) can pose a number of risks to water quality and public health due to the amount of animal manure and wastewater they generate. To minimize water quality and public health impacts from AFOs and land applications of animal waste, the USDA and EPA released the Unified National Strategy for AFOs in 1999 (NRCS 2005). This strategy encourages owners of AFOs of any size or number of animals to voluntarily develop and implement site-specific Comprehensive Nutrient Management Plans (CNMPs) by 2009. This plan is a written document detailing manure storage and handling systems, surface runoff control measures, mortality management, chemical handling, manure application rates, schedules to meet crop nutrient needs, land management practices, and other options for manure disposal. An AFO that meets certain specified criteria is referred to as a Concentrated Animal Feeding Operation (CAFO), and in addition may be required to obtain a Montana Pollution Discharge Elimination System (MPDES) permit as a point source. Montana's AFO compliance strategy is based on federal law and has voluntary, as well as, regulatory components. If voluntary efforts can eliminate discharges to state waters, in some cases no direct regulation is necessary through a permit. Operators of AFOs may take advantage of effective, low cost practices to reduce potential runoff to state waters, which additionally increase property values and operation productivity. Properly installed vegetative filter strips, in conjunction with other practices to reduce waste loads and runoff volume, are very effective at trapping and detaining sediment and reducing transport of nutrients and pathogens to surface waters, with removal rates approaching 90 percent (NRCS 2005). Other options may include clean water diversions, roof gutters, berms, sediment traps, fencing, structures for temporary manure storage, shaping, and grading. Animal health and productivity also benefit when clean, alternative water sources are installed to prevent contamination of surface water. Studies have shown benefits in red meat and milk production of 10 to 20 percent by livestock and dairy animals when good quality drinking water is substituted for contaminated surface water.

Opportunities for financial and technical assistance (including CNMP development) in achieving voluntary AFO and CAFO compliance are available from conservation districts and NRCS field offices. Voluntary participation may aide in preventing a more rigid regulatory program from being implemented for Montana livestock operators in the future.

Further information may be obtained from the DEQ website at: http://www.deq.mt.gov/wqinfo/mpdes/cafo.asp. Montana's NPS pollution control strategies for addressing AFOs are summarized in the bullets below:

- Work with producers to prevent NPS pollution from AFOs.
- Promote use of State Revolving Fund for implementing AFO BMPs.
- Collaborate with MSU Extension Service, NRCS, and agriculture organizations in providing resources and training in whole farm planning to farmers, ranchers, conservation districts, watershed groups and other resource agencies.
- Encourage inspectors to refer farmers and ranchers with potential nonpoint source discharges to DEQ watershed protection staff for assistance with locating funding sources and grant opportunities for BMPs that meet their needs. (This is in addition to funds available through NRCS and the Farm Bill).

- Develop early intervention of education & outreach programs for small farms and ranches that have potential to discharge nonpoint source pollutants from animal management activities. This includes assistance from the DEQ internal (Permitting Division), as well as external entities (DNRC, local watershed groups, conservation districts, MSU Extension, etc.).

9.5.3 Cropland

The primary strategy of the recommended cropland BMPs is to reduce sediment and nutrient inputs. The major factors involved in decreasing sediment loads are reducing the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil before it enters water bodies. The main BMP recommendations for the upper Clark Fork watershed are vegetated filter strips (VFS) and riparian buffers. Both of these methods reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept sediment. Effectiveness is typically about 70 percent for filter strips and 50 percent for buffers (DEQ 2007). Filter strips and buffers are most effective when used in conjunction with agricultural BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, stripcropping, and precision farming. Additional BMPs and details on the suggested BMPs can be obtained from NRCS and in **Appendix A** of Montana's NPS Management Plan (DEQ 2007).

Reducing sediment loading will decrease loading of sediment-bound nutrients, but nutrient management is also needed to reduce nutrient loading. Nutrient management is managing the amount, source, placement, form, and timing of plant nutrients and soil amendments. Nutrient management components of the conservation plan should include the following information (NRCS MT 590-1):

- Field maps and soil maps,
- Planned crop rotation or sequence,
- Results of soil, water, plant, and organic materials sample analysis,
- Realistic expected yields,
- Sources of all nutrients to be applied,
- Nutrient budget, including credits of nutrients available,
- Nutrient rates, form, timing, and application method to meet crop demands and soil quality concerns,
- Location of designated sensitive areas, and
- Guidelines for operation and maintenance.

More information about nutrient management techniques can be found at your local NRCS office or in the NRCS publication MT 590-1.

9.5.4 Irrigation

Flow alteration and dewatering are commonly considered water quantity rather than water quality issues. However, changes to stream flow can have a profound effect on the ability of a stream to attenuate pollutants, especially nutrients, metals and heat. Flow reduction may increase water temperature, allow sediment to accumulate in stream channels, reduce available habitat for fish and other aquatic life, and may cause the channel to respond by changing in size, morphology, meander pattern, rate of migration, bed elevation, bed material composition, floodplain morphology, and streamside vegetation if flood flows are reduced (Andrews and Nankervis 1995, Schmidt and Potyondy 2004). Restoration targets and implementation strategies recognize the need for specific flow regimes, and may recommend flow-related recommendations and enhancements as a means to achieve full support of beneficial uses. However, local coordination and planning are especially important for flow management because State law indicates that legally obtained water rights cannot be divested, impaired, or diminished by Montana's water quality law (MCA 75-5-705).

Irrigation management is a critical component of attaining both cold water fishery conservation and TMDL goals. Irrigation efficiency management practices in the upper Clark Fork should involve investigating how to reduce the amount of stream water diverted during July and August, while still growing crops on traditional cropland. It may be desirable to investigate irrigation practices earlier in the year that promote ground water return during July and August. Understanding irrigation water, ground water and surface water interactions is an important part of understanding how irrigation practices will affect stream flow during specific seasons.

9.5.4.1 Irrigation Flow Restoration Recommendations

Improving Irrigation Efficiency During Low Streamflow Timeframes
Many of the irrigation practices in the upper Clark Fork watershed are based in flood irrigation methods. In some cases, head gates and ditches leak, which can decrease the amount of water in-channel flows. The following recommended activities would result in notable water savings:

- Install upgraded head gates for more exact control of water diversions and to minimize leakage when not in operation.
- Develop more efficient means to supply water to livestock.
- Determine necessary amounts of water to divert that would reduce over watering and improve forage quality and production.
- Redesign irrigation systems.
- Upgrade ditches (including possible lining) to increase ditch conveyance efficiency.

Future studies could investigate irrigation water return flow timeframes from specific areas along the Clark Fork River tributaries. A portion of spring and early summer flood irrigation water likely returns as cool ground water to the streams during the heat of the summer. These critical areas could be identified so that they can be preserved as flood irrigation areas. Other irrigated areas which do not contribute to summer ground water returns to the river should be identified as areas were year round irrigation efficiencies could be more beneficial to preserving flow in the stream during hot summer timeframes. Winter baseflow should also be considered during these investigations.

9.5.5 Riparian Vegetation

Reduction of riparian vegetative cover by various land management activities is a principal cause of water quality and habitat degradation in the Upper Clark Fork TPA. Although implementation of passive BMPs that allow riparian vegetation to recover at natural rates is typically the most cost-effective approach, active restoration (i.e. plantings) may be necessary in some instances. The primary advantage of riparian plantings is that installation can be accomplished with minimum impact to the stream channel, existing vegetation, and private property. In addition to providing shade (and possible reduced water temperature) and cover for aquatic species, riparian plantings can develop root masses that penetrate deep into the soils, increasing bank resilience to erosion. All areas that are actively restored with vegetation must have a reasonable approach to protecting the invested effort from further degradation from livestock or hay production.

Factors influencing the appropriate riparian restoration would include severity of degradation, site-potential for various species, and availability of local sources for transplant materials. In general, riparian plantings would promote establishment of functioning stands of native species (grasses and willows). The following recommended restoration measures would allow for stabilization of the soil, decreasing sediment delivery to the stream, and increasing absorption of nutrients from overland runoff:

- Harvest and transplant locally available sod mats with an existing dense root mass which provide immediate promotion of bank stability and filtering nutrients and sediments.
- Transplanting mature shrubs, particularly willows (*Salix* sp.), provides rapid restoration of instream habitat and water quality through overhead cover and stream shading as well as uptake of nutrients.
- Seeding with native graminoids (grasses and sedges) and forbs is a low cost activity where lower bank shear stresses would be unlikely to cause erosion.
- Willow sprigging would expedite vegetative recovery, involving harvest of dormant willow stakes from local sources.

9.5.6 Unpaved Roads

The road sediment reductions in this document represent a gross estimation of the sediment load that would remain once road BMPs were applied, assuming no current BMPs are in place. The estimated load per contributing crossing was based on a review of a number of studies that were conducted throughout western Montana. In general, a road with associated BMPs assumes contributing road treads, cut slopes, and fill slopes were reduced to 100 feet (from each side of a crossing). This distance is selected as an example to illustrate the potential for sediment reduction through BMP application and is not a formal goal at every crossing. For example, many roads may easily have a smaller contributing length, while others may not be able to meet a 100ft milestone. Achieving this reduction in sediment loading from roads may occur through a variety of methods at the discretion of local land managers and restoration specialists. Road BMPs can be found on the Montana DEQ or DNRC websites and within Montana’s NPS Management Plan (DEQ, 2007). Examples include:

- Providing adequate ditch relief up-grade of stream crossings.
- Constructing waterbars, where appropriate, and up-grade of stream crossings.
- Instead of cross pipes, using rolling dips on downhill grades with an embankment on one side to direct flow to the ditch. When installing rolling dips, ensure proper fillslope stability and sediment filtration between the road and nearby streams.

- Insloping roads along steep banks with the use of cross slopes and cross culverts.
- Outsloping low traffic roads on gently sloping terrain with the use of a cross slope.
- Using ditch turnouts and vegetative filter strips to decrease water velocity and sediment carrying capacity in ditches.
- For maintenance, grading materials to the center of the road and avoiding removing the toe of the cutslope.
- Preventing disturbance to vulnerable slopes.
- Using topography to filter sediments; flat, vegetated areas are more effective sediment filters.
- Where possible, limit road access during wet periods when drainage features could be damaged.

9.5.6.1 Culverts

Although culverts were not part of the source assessment, they can be large sources of sediment, and should be included in the restoration strategy. A field survey should be conducted and combined with local knowledge to prioritize culverts for restoration. As culverts fail, they should be replaced by culverts that pass a 100 year flood on fish bearing streams and at least 25 year events on non fish bearing streams. Culverts should be at grade with the streambed, and inlets and outlets should be vegetated and armored. Some road crossings may not pose a feasible situation for upgrades to these sizes because of road bed configuration; in those circumstances, the largest size culvert feasible should be used.

Another consideration for culvert upgrades will be providing fish passage. During the assessment and prioritization of culverts, additional crossings should be assessed for streams where fish passage is a concern. Each fish barrier should be assessed individually to determine if it functions as an invasive species and/or native species barrier. These two functions should be weighed against each other to determine if each culvert acting as a fish passage barrier should be mitigated. Montana FWP can aid in determining if a fish passage barrier should be mitigated, and, if so, it should be involved in culvert design. If funding is available, culverts should be prioritized and replaced prior to failure.

9.5.7 Bank hardening/riprap/revetment/floodplain development

The use of riprap or other “hard” approaches is not recommended and is not consistent with water quality protection or implementation of this plan. Although it is necessary in some instances, it generally redirects channel energy and exacerbates erosion in other places. Bank armoring should be limited to areas with a demonstrated infrastructure threat. Where deemed necessary, apply bioengineered bank treatments to induce vegetative reinforcement of the upper bank, reduce stream scouring energy, and provide shading and cover habitat. Limit infrastructure threats by reducing floodplain development through land use planning initiatives.

Bank stabilization using natural channel design techniques can provide both bank stability and habitat potential. The primary recommended structures are large woody debris jams. These natural arrays can be constructed to emulate historical debris assemblages that were introduced to the channel by the adjacent cottonwood dominated riparian community types. When used in together, woody debris jams and straight log vanes can benefit the stream and fishery by improving bank stability, reducing bank erosion rates, adding protection to fill slopes and/or embankments, reducing near-bank shear stress, and enhancing aquatic habitat and lateral channel margin complexity.

9.5.8 Forestry and Timber Harvest

Currently, timber harvest is not significantly affecting sediment production in the Upper Clark Fork TPA, but harvesting will likely continue in the future within the Beaverhead Deerlodge National Forest (BDNF), Helena National Forest (HNF) and on private land. Future harvest activities should be conducted by all landowners according to Forestry BMPs for Montana (MSU Extension Service 2001) and the Montana SMZ Law (77-5-301 through 307 MCA). The Montana Forestry BMPs cover timber harvesting and site preparation, harvest design, other harvesting activities, slash treatment and site preparation, winter logging, and hazardous substances. While the SMZ Law is intended to guide commercial timber harvesting activities in streamside areas (i.e. within 50 feet of a water body), the riparian protection principles behind the law can be applied to numerous land management activities (i.e. timber harvest for personal use, agriculture, development). Prior to harvesting on private land, landowners or operators are required to notify the Montana DNRC. DNRC is responsible for assisting landowners with BMPs and monitoring their effectiveness. The Montana Logging Association and DNRC offer regular Forestry BMP training sessions for private landowners.

Timber harvest should not increase the peak water yield by more than 10 percent of historic conditions. If a natural disturbance, such as a forest fire, increases peak water yield, the increase should be accounted for as part of timber harvest management.

9.5.9 Mining/Smelter Fallout-Related

Because restoration of metals sources that are not also associated with sediment are typically implemented under state and federal programs, this section will discuss general restoration programs and funding mechanisms that may be applicable to the metals sources instead of specific BMPs. The need for further characterization of impairment conditions and loading sources is addressed through the framework monitoring plan in **Section 10.0**. A number of state and federal regulatory programs have been developed over the years to address water quality problems stemming from historic mines, associated disturbances, and metal refining impacts. Some regulatory programs and approaches considered most applicable to the upper Clark Fork watershed include:

- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA),
- The State of Montana Mine Waste Cleanup Bureau’s Abandoned Mine Lands (AML) Reclamation Program,
- The Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA), which incorporates additional cleanup options under the Controlled Allocation of Liability Act (CALA) and the Voluntary Cleanup and Redevelopment Act (VCRA).

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
CERCLA (a.k.a. Superfund) is a Federal law that addresses cleanup on sites, such as historic mining areas, where there has been a hazardous substance release or threat of release. Sites are prioritized on the National Priority List (NPL) using a hazard ranking system with significant focus on human health. Under CERCLA, the potentially responsible party or parties must pay for all remediation efforts based upon the application of a strict, joint and several liability approach whereby any existing or historical land owner can be held liable for restoration costs. Where viable landowners are not available to fund cleanup, funding can be provided under Superfund authority. Federal agencies can be delegated Superfund authority, but cannot access funding from Superfund.

Cleanup actions under CERCLA must be based on professionally developed plans and can be categorized as either Removal or Remedial. Removal actions can be used to address the immediate need to stabilize or remove a threat where an emergency exists. Removal actions can also be non-time critical.

Once removal activities are completed, a site can then undergo Remedial Actions or may end up being scored low enough from a risk perspective that it no longer qualifies to be on the NPL for Remedial Action. Under these conditions the site is released back to the state for a "no further action" determination. At this point there may still be a need for additional cleanup since there may still be significant environmental threats or impacts, although the threats or impacts are not significant enough to justify Remedial Action under CERCLA. Any remaining threats or impacts would tend to be associated with wildlife, aquatic life, or aesthetic impacts to the environment or aesthetic impacts to drinking water supplies versus threats or impacts to human health. A site could, therefore, still be a concern from a water quality restoration perspective, even after CERCLA removal activities have been completed.

Remedial actions may or may not be associated with or subsequent to removal activities. A remedial action involves cleanup efforts whereby Applicable or Relevant and Appropriate Requirements and Standards (ARARS), which include state water quality standards, are satisfied. Once ARARS are satisfied, then a site can receive a "no further action" determination.

As discussed within the Watershed Characterization (**Section 2.0**), there are four contiguous CERCLA sites within the Upper Clark Fork watershed. The Milltown Reservoir/Clark Fork River NPL Site includes the floodplain of the Clark Fork River, and therefore may include the mouth of Clark Fork tributaries addressed within this document, but for the most part, there are two sites that address mining wastes within tributary watersheds of the Upper Clark Fork TPA. They are the Anaconda Smelter and Butte/Silver Bow NPL sites.

Montana Mine Waste Cleanup Bureau Abandoned Mine Reclamation Program (AML)
The Mine Waste Cleanup Bureau (MWCB), which is part of the DEQ Remediation Division, is responsible for reclamation of historical mining disturbances associated with abandoned mines in Montana.

The MWCB abandoned mine reclamation program is funded through the Surface Mining Control and Reclamation Act of 1977 (SMCRA) with SMCRA funds distributed to states by the federal government. In order to be eligible for SMCRA funding, a site must have been mined or affected by mining processes, and abandoned or inadequately reclaimed, prior to August 3, 1977 for private lands, August 28, 1974 for Forest Service administered lands, and prior to 1980 for lands administered by the U.S. Bureau of Reclamation. Furthermore, there must be no party (owner, operator, other) who may be responsible for reclamation requirements, and the site must not be located within an area designated for remedial action under the federal Superfund program or certain other programs. Both priority abandoned mines within metals-listed watersheds are in the Dunkleberg Creek watershed. They include Forest Rose (DEQ priority ranking = 15/138) and Jackson Park (DEQ priority ranking = 96/138).

Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA)
Reclamation of historic mining-related disturbances administered by the State of Montana and not addressed under SMCRA, are typically addressed through the DEQ State Superfund or CECRA program. The CECRA program maintains a list of facilities potentially requiring response actions based on the confirmed release or substantial threat of a release of a hazardous or deleterious substance that may pose an imminent and substantial threat to public health, safety or welfare or the environment (ARM 17.55.108). Listed facilities are prioritized as maximum, high, medium, or low priority or in operation and maintenance status based on the potential threat posed. Currently, there are no active sites on the CECRA priority list in the upper Clark Fork watershed along metals-listed water bodies being addressed within this document.

CECRA also encourages the implementation of voluntary cleanup activities under the Voluntary Cleanup and Redevelopment Act (VCRA), and the Controlled Allocation and Redevelopment Act (CALA). It is possible that any historic mining-related metals loading sources identified in the watershed in the future could be added to the CECRA list and addressed through CECRA, with or without the VCRA and/or CALA process. A site can be added to the CECRA list at DEQ's initiative, or in response to a written request made by any person to the department containing the required information.

Other Programs
In addition to the programs discussed above, other funding may be available for water quality restoration activities. These sources include the following:

- Upper Clark Fork River Basin Grant Program (UCFRB)
- Resource Indemnity Trust/Reclamation and Development Grants Program (RIT/RDGP)
- EPA Section 319 Nonpoint Source Grant Program

<u>UCFRB</u>
The State of Montana was awarded monies through a series settlement agreements signed between 1999 and 2008 against the Atlantic Richfield Company (ARCO) as a result the extensive mining-related damages to natural resources within the Upper Clark Fork watershed. The Natural Resource Damage Program (NRDP), which is part of the Montana Department of Justice, filed the lawsuit and administers a grant process as a way to disperse the settlement funds. Government agencies and private entities/individuals are eligible for the grant funding, and UCFRB is a unique opportunity for remediation in the Upper Clark Fork TPA because

funding must be applied within the Upper Clark Fork watershed. Several types of projects are eligible for funding but those most applicable to TMDL implementation are *restoration projects* and *monitoring and research project*s. UCFRB is an annual program and has a slightly different application process for grants under $25,000 than for those over $25,000. Certain areas that are still being investigated as part of the Superfund sites are not eligible for funding.

<u>RIT/RDGP</u>
The RIT/RDG is an annual program that can provide up to $300,000 to address environmental related issues. This money can be applied to sites included on the Mine Waste Cleanup Bureau's Abandoned Mine Lands (AML) priority list, but of low enough priority where cleanup under AML is uncertain. RIT/RDG program funds can also be used for conducting site assessment/ characterization activities such as identifying specific sources of water quality impairment.

<u>Section 319 funding</u>
Section 319 grant funds are typically used to help identify, prioritize, and implement water quality protection projects with focus on TMDL development and implementation of nonpoint source projects. Individual contracts under the yearly grant typically range from $20,000 to $150,000, with a 25 percent or more match requirement. RIT/RDG and 319 projects typically need to be administered through a non-profit or local government such as a conservation district, a watershed planning group, or a county.

Program Overlap and Coordination
Within the Upper Clark Fork watershed, large scale metals-related restoration work and project prioritization is occurring by both government agencies and stakeholder groups. The major agencies involved are the EPA, MT Department of Justice (via the NRDP), and DEQ. EPA and State-lead Superfund efforts are starting to wrap up at the Silver Bow Creek/Butte Area and Anaconda Smelter Superfund sites and will be shifting more to operation and maintenance over the next few years, but the process is just starting to gear up at the Milltown Reservoir Sediments/Clark Fork River Superfund Site. The NRDP is currently working with FWP to develop a joint priority list of streams and project types for the entire Upper Clark Fork watershed, and it is based on an assessment of fish populations, stream habitat, and the capacity for improvement. Although a draft list will likely be completed in early 2010, because of ongoing research within the basin, the list is not intended to be static. DEQ's Abandoned Mine Land program is continuing to address remediation at priority abandoned mines within the Upper Clark Fork tributaries, which includes an upcoming follow-up assessment at the Forest Rose Mine on Dunkleberg Creek. DEQ's TMDL program intends to develop metals TMDLs for other upper Clark Fork River tributaries (e.g. Little Blackfoot River, Flint Creek, and Silver Bow Creek) as well as the mainstem Clark Fork River over the next few years, and the Water Quality Monitoring program will incorporate available data into new water body assessments and/or reassessments as resources allow.

This TMDL document is focused on metals impairment and restoration (in addition to the other pollutants addressed) in 303(d) listed streams, but the locally-driven WRP, which will be developed over the next year, will have a broader focus and should identify agency stakeholders and their priorities within the watershed, as well as local restoration priorities. Similar to the

NRDP priority list, the WRP is intended to be a “living document”, in that it should be maintained and adapted as new information becomes available and priorities change.

All of the agencies are actively collaborating to promote the exchange of information and to try to avoid duplicative efforts within the Upper Clark Fork basin (and the rest of the watershed). Because of varying agency and stakeholder goals and priorities, a fully concerted restoration effort is not possible. However, the high level of inter-agency collaboration, as well as the inclusion of stakeholders, is encouraged to continue and should help increase the efficiency and cost-effectiveness of restoration in areas of overlap and also to identify where gaps may exist.

SECTION 10.0
MONITORING STRATEGY AND ADAPTIVE MANAGEMENT

10.1 Introduction

The monitoring strategies discussed in this section are an important component of watershed restoration, a requirement of TMDL development under Montana's TMDL law, and the foundation of the adaptive management approach. Water quality targets and allocations presented in this document are based on available data at the time of analysis, however the scale of the watershed coupled with constraints on time and resources often result in compromises that must be made that include estimations, extrapolation, and a level of uncertainty. The margin of safety (MOS) is put in place to reflect some of this uncertainty, but other issues only become apparent when restoration strategies are underway. Having a monitoring strategy in place allows for feedback on the effectiveness of restoration activities (whether TMDL targets are being met), if all significant sources have been identified, and whether attainment of TMDL targets is feasible. Data from long-term monitoring programs also provide technical justifications to modify restoration strategies, targets, or allocations where appropriate.

The monitoring strategy presented in this section provides a starting point for the development of more detailed and specific planning efforts regarding monitoring needs; it does not assign monitoring responsibility. Monitoring recommendations provided are intended to assist local land managers, stakeholder groups, and federal and state agencies in developing appropriate monitoring plans to meet aforementioned goals. Funding for future monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on stakeholder priorities for restoration and funding opportunities.

10.2 Adaptive Management Approach

An adaptive management approach is recommended to control costs and meet the water quality standards to support all beneficial uses. This approach works in cooperation with the monitoring strategy, and as new information is collected, it allows for adjustments to restoration goals or pollutant targets, TMDLs, and/or allocations, as necessary.

10.3 Future Monitoring Guidance

The objectives for future monitoring in the upper Clark Fork watershed include:

- Strengthen the spatial understanding of sources for future restoration work, which will also strengthen source assessment analysis for future TMDL review.
- Gather additional data to supplement target analysis, better characterize existing conditions, and improve or refine assumptions made in TMDL development.
- Gather consistent information among agencies and watershed groups that is comparable to targets and allows for common threads in discussion and analysis.
- Expand the understanding of streams throughout the upper Clark Fork beyond those where TMDLs have been developed and address issues if necessary.

- Track restoration projects as they are implemented and assess their effectiveness.

10.3.1 Strengthening Source Assessment

In the Upper Clark Fork TPA, the identification of sources was conducted largely through watershed field tours, aerial assessment, the incorporation of GIS information, available data and literature review, with limited field verification and on-the-ground analysis. In many cases, assumptions were made based on overall TPA conditions and extrapolated throughout the watershed. As a result, the level of detail often does not provide specific areas by which to focus restoration efforts, only broad source categories to reduce sediment loads from in each of the discussed subwatersheds. Strategies for strengthening source assessments for each of the pollutants may include:

Sediment
Field surveys of culverts, roads, and road crossings to identify specific contributing road associated loads, and prioritize those road segments/crossings of most concern. Culverts should be assessed for their ability to pass certain flows (typically 100-year flood events) as culvert failure is often a source of discrete sediment loads. Undersized culverts also prohibit fish passage during certain flows.

Review of land use practices specific to subwatersheds of concern to determine where the greatest potential for improvement and likelihood of sediment reduction can occur for the identified major land use categories.

More thorough examinations of bank erosion conditions and investigation of related contributing factors for each subwatershed of concern through site visits and subwatershed scale BEHI assessments. Additionally, the development of bank erosion retreat rates specific to the Upper Clark Fork TPA would provide a more accurate quantification of sediment loading from bank erosion. Bank retreat rates can be determined by installing bank pins at different positions on the streambank at several transects across a range of landscapes and stability ratings. Bank erosion is documented after high flows and throughout the year for several years to capture retreat rates under a range of flow conditions.

Temperature
Broader examination of riparian shade conditions in Peterson Creek through Solar Pathfinder monitoring and riparian greenline assessment to better characterize existing conditions and prioritize areas in need of riparian improvement.

Multi-year temperature and flow monitoring at all significant flow input and output locations including irrigation withdrawal and return locations during the hottest months of the year.

Metals
Because of both limited data and the complexity of sources, many of the TMDL allocations to mining sources are clumped into composite allocations. In watersheds with composite WLAs to unpermitted point sources and in watersheds with composite LAs to diffuse mining-related sources that also include some abandoned mines or mining wastes, follow up monitoring should

focus on defining the contribution from abandoned mines and other discrete mining sources. Although many of the mines in the DEQ and/or MBMG databases have been visited to determine the location and condition of abandoned mines, in most cases the contribution from individual abandoned mines is unknown. Additionally, there may be discrete abandoned mine sources that are contributing to exceedances of metals targets that are not identified in either of the State databases. For instance, follow up monitoring in the Gold Creek watershed should include characterizing loading, particularly for iron and lead, from abandoned mines or other mining-related sources (e.g. mining wastes/deposits) in the lower watershed, and follow up monitoring in the lower Mill Creek watershed should investigate the abandoned mines near Smelter Hill. As additional information becomes available regarding contributions from abandoned mines, TMDLs may be modified via adaptive management to split composite WLAs into separate WLAs and/or to develop WLAs for discrete mining sources in watersheds dominated by non-point source loading that currently have a composite LA.

Priority abandoned mines in the Dunkleberg Creek watershed were assessed in the early 1990s and 2000s, but conditions and source areas at those mines may have changed since then, and additional monitoring is recommended to determine the nature of reclamation work required to meet TMDLs.

Monitoring is also recommended within irrigation ditches to help determine which ditches are significant sources of metals loading to metals-impaired water bodies.

Because the contribution from placer-mined areas is unknown, additional source assessment and monitoring within the Gold and Peterson creek watersheds should include areas that were historically placer-mined.

10.3.2 Increase Available Data

While the Upper Clark Fork watershed has been the recipient of significant remediation and restoration activities, data is still often limited depending on the stream and pollutant of interest. Infrequent sampling events at a small number of sampling sites may provide some indication of overall water quality and habitat condition, however regularly scheduled sampling at consistent locations, under a variety of seasonal conditions is the best way to assess overall stream health and monitor change, and as in **10.3.1** improves source assessment analysis.

Sediment

For sediment investigation in the Upper Clark Fork, each of the streams of interest was stratified into unique reaches based on physical characteristics and anthropogenic influence. A total of 25 sites were sampled throughout the watershed, however this equates to only a small percentage of the total number of stratified reaches, and even less on a stream by stream basis. Sampling additional monitoring locations to represent some of the various reach categories that occur would provide additional data to assess existing conditions, and provide more specific information on a per stream basis as well as the TPA as a whole, by which to assess reach by reach comparisons and the potential influencing factors and resultant outcomes that exist throughout the watershed.

Temperature
Multiple temperature data loggers deployed throughout a watershed of interest so as to understand the thermal changes that occur as a result of changes in flow, land use, and shifts in hydrology. Data logger deployment and flow measurements should be conducted such that tributaries, ponds, lakes, springs, ground water upwelling, and water withdrawls and returns are represented. Annual temperature investigations at recurring locations will also be necessary to illustrate seasonal and annual variation.

Metals
Regular data collection (including flow) at consistent locations and at multiple locations within a watershed of interest such that source areas or suspected source areas are bracketed and metal concentration changes can be discerned throughout the watershed. Monitoring should also include monitoring of background concentrations at high and low flow, because much of the existing background data in the Upper Clark Fork were limited in quantity or only collected at low flow. Monitoring at high and low flow provides indication as to relevant sources at various times of the year and helps discern metals inputs between ground water and surface runoff.

10.3.3 Consistent Data Collection and Methodologies

Data has been collected throughout the Upper Clark Fork TPA for many years and by many different agencies and entities, however the type and quality of information is often variable. Where ever possible, it is recommended that the type of data and methodologies used to collect and analyze the information be consistent so as to allow for comparison to TMDL targets and track progress toward meeting TMDL goals.

The Montana Department of Environmental Quality (DEQ) is the lead agency for developing and conducting impairment status monitoring. However, other agencies or entities may work closely with DEQ to provide compatible data if interest arises. Impairment determinations are conducted by the state but can use data collected from other sources. The information in this section provides general guidance for future impairment status monitoring and effectiveness tracking.

It is important to note that monitoring recommendations are based on TMDL related efforts to protect beneficial uses in a manner consistent with Montana's water quality standards. Other regulatory programs with water quality protection responsibilities may impose additional requirements to ensure full compliance with all appropriate local, State and Federal laws. For example, reclamation of a mining related source of metals under CERCLA and CECRA typically requires source-specific sampling requirements, which cannot be defined at this time, to determine the extent of and the risk posed by contamination, and to evaluate the success of specific remedial actions.

Sediment
Sediment and habitat assessment protocols consistent with DEQ field methodologies and that serve as the basis for sediment targets and assessment within this TMDL should be conducted whenever possible. Current protocols are identified within (DEQ 2009). It is acknowledged that various agencies and entities have differing objectives, as well as time and resources available to

achieve those objectives. However, when possible, when collecting sediment and habitat data in the Upper Clark Fork it is recommended that at a minimum the following parameters be collected to allow for comparison to TMDL targets:

- Riffle Cross Section; using Rosgen methodology
- Riffle Pebble Count; using Wolman Pebble Count methodology
- Pool Assessment; Count and Residual Pool Depth Measurements
- Greenline Assessment; NRCS methodology

Additional information will undoubtedly be useful and assist DEQ with TMDL effectiveness monitoring in the future. Macroinvertebrate studies, McNeil core sediment samples, and fish population surveys and redd counts are examples of additional useful information used in impairment status monitoring and TMDL effectiveness monitoring which were not developed as targets but reviewed where available during the development of this TMDL.

Temperature

Monitoring (including instrument calibration) should be conducted in accordance with the DEQ's Field Procedures Manual (DEQ 2005). For each site, a site form (Continuous Data Logger Field Form) information should be completed that includes GPS coordinates, time, weather, a hand drawn site sketch indicating temperature logger locations and any other observations. Instantaneous flow should be measured when the temperature loggers are deployed and when they are retrieved. Stream discharge data should be collected using a *Marsh McBirney Flo-Mate 2000*™ or similar, current velocity meter and standard USGS area-velocity method. Solar Pathfinder data should be collected according to standard methods and procedures provided with the Solar Pathfinder.

Metals

Standards attainment monitoring should include analysis of a suite of total recoverable metals (e.g. As, Cu, Cd, Pb, Zn), sediment samples, hardness, pH, and TSS for all pollutant-water body combinations. As a result of water and sediment data collected during TMDL development, TMDLs were developed for several metals that were not on the 2006 303(d) List, and TMDLs were not developed for some listed metals because recent data did not exceed water quality targets and/or anthropogenic sources were not identified. Based on the data evaluations within this document (**Section 7.4.4**), several metals have been identified as priorities for future metals monitoring (**Table 10-1)**.

Table 10-1. Metals Monitoring Recommendations.
"--" indicates no recommendation, HF = high flow, and LF = low flow.

Water Body Segment ID	Water Body Segment	Recommended Monitoring	Recommended 303(d) Assessment (& Rationale)
MT76G003_031	Beefstraight Creek	CN; Cu (water column and in sediment)	--
MT76G005_071	Dunkleberg Creek (upper)	As, Cd, Zn	As, Cu, Fe (potential new listings)

Table 10-1. Metals Monitoring Recommendations.
"--" indicates no recommendation, HF = high flow, and LF = low flow.

Water Body Segment ID	Water Body Segment	Recommended Monitoring	Recommended 303(d) Assessment (& Rationale)
MT76G005_072	Dunkleberg Creek (lower)	As, Cd, Cu, Fe, Zn; particularly near the mouth during LF	As, Cd, Cu, Fe, Zn (potential new listings)
MT76G003_030	German Gulch	As (particularly at LF)	As, CN (potential new listings)
MT76G005_091	Gold Creek (upper)	Pb	--
MT76G005_092	Gold Creek (lower)	Fe, Pb	Fe, Pb (potential new listings)
MT76G002_072	Lost Creek (lower)	SO_4	Cu, Pb (potential new listings); Fe, Mn, SO_4 (potential delistings)
MT76G002_051	Mill Creek (upper)	As, Cu, Zn (HF); Cr,	Cr (potential delisting)
MT76G002_052	Mill Creek (lower)	Al	Al (potential delisting)
MT76G002_120	Mill-Willow Bypass	Cd, Zn	Cd, Zn (potential new listings)
MT76G002_080	Modesty Creek	Cd, Cu, Pb	Cd, Cu, Pb (potential new listings)
MT76G002_131	Peterson Creek (upper)	Fe, Pb	Fe, Pb (potential new listings)
MT76G002_132	Peterson Creek (lower)	As, Fe	Fe (potential new listing)
MT76G002_012	Warm Springs Creek (lower)	--	Cd, Fe, Zn (potential new listings)
MT76G002_061	Willow Creek (upper)	Fe, Zn	Fe, Zn (potential new listings)
MT76G002_062	Willow Creek (lower)	Fe, Zn	Fe, Zn (potential new listings)

10.3.4 Effectiveness Monitoring for Restoration Activities

As restoration activities are implemented, watershed-scale monitoring may be valuable in determining if restoration activities are improving water quality, instream flow, and aquatic habitat and communities. It is important to remember that degradation of aquatic resources happens over many decades and that restoration is also a long-term process. An efficiently executed long-term monitoring effort is an essential component to any restoration effort.

Due to the natural high variability in water quality conditions, trends in water quality are difficult to define and even more difficult to relate directly to restoration or other changes in management. Improvements in water quality or aquatic habitat from restoration activities will most likely be evident in fine sediment deposition and channel substrate embeddedness, changes in channel cumulative width/depths, improvements in bank stability and riparian habitat, increases in instream flow, and changes in communities and distribution of fish and other bio-indicators. Specific monitoring methods, priorities, and locations will depend heavily on the type of restoration projects implemented, landscape or other natural setting, the land use influences specific to potential monitoring sites, and budget and time constraints.

As restoration activities begin throughout the watershed, pre and post monitoring so as to understand the change that follows will be necessary to track the effectiveness of specific given practices or implementation projects. The following recommendations are categorized by the type of restoration practice to which they apply.

10.3.4.1 Road BMPs

Monitoring road sediment delivery is necessary to determine if BMPs are effective, to determine which are most effective, and to determine which practices or sites require modification to achieve water quality goals. Effectiveness monitoring should be initiated before implementing BMPs at treatment sites.

Monitoring actual sediment routing is difficult or prohibitively expensive. It is likely that budget constraints will influence the number of monitored sites. Once specific restoration projects are identified, a detailed monitoring study design should be developed. To overcome environmental variances, monitoring at specific locations should continue for a period of two to three years after BMPs are initiated.

Specific types of monitoring for separate issues and improvements are listed in **Table 10-2**.

Table 10-2. Monitoring Recommendations for Road BMPs

Road Issue from Section 9.0 (Restoration)	**Restoration Recommendation**	**Monitoring Recommendation**	**Recommended Methodology**
Ditch Relief Combined with Stream Crossings	Re-engineer & rebuild roads to completely disconnect stream sloped ditches from stream crossings. Techniques may include: • Ditch relief culverts • Rolling dips • Water Bars • Outsloped roads • Catch basins • Raised road grade near stream crossing	• Place silt trap directly upslope of tributary crossing to determine mass of sediment routed to that point. • Rapid inventory to document improvements and condition.	• Sediment yield monitoring based on existing literature/USFS methods. • Revised Washington Forest Practices Board methodology.

Table 10-2. Monitoring Recommendations for Road BMPs

Road Issue from Section 9.0 (Restoration)	**Restoration Recommendation**	**Monitoring Recommendation**	**Recommended Methodology**
Ditch Relief Culverts	• Consider eliminating the stream sloped-inward sloped ditch and outsloping the road or provide rolling dips. • When maintaining/ cleaning ditch, do not disturb toe of cutslope. • Install culverts with proper slope and angle following Montana road BMPs. • Armor culvert outlets. • Construct stable catch basins. • Vegetate cutslopes above ditch. • Increase vegetation or install slash filters. • Provide infiltration galleries where culvert outlets are near a stream.	• Rapid inventory to document improvements and condition. • Silt traps below any ditch relief culvert outlets close to stream.	• Revised Washington Forest Practices Board methodology. • Sediment yield monitoring based on existing literature/USFS methods.
Stream Crossings	• Place culverts at streambed grade and at base of road fill. • Armor and/or vegetate inlets and outlets. • Use proper length and diameter of culvert to allow for flood flows and to extend beyond road fill.	• Repeat road crossing inventory after implementation. • Fish passage and culvert condition inventory.	• Revised Washington Forest Practices Board methodology. • Montana State (DNRC) culvert inventory methods.
Road Maintenance	• Avoid casting graded materials down the fill slope & grade soil to center of road, compact to re-crown. • Avoid removing toe of cut slope. • In some cases graded soil may have to be removed or road may have to be moved.	• Repeat road inventory after implementation. • Monitor streambed fine sediment (grid or McNeil core) and sediment routing to stream (silt traps) below specific problem areas.	• Revised Washington Forest Practices Board methodology. • Standard sediment monitoring methods in literature.
Oversteepened Slopes/General Water Management	• Where possible outslope road and eliminate inboard ditch. • Place rolling dips and other water diverting techniques to improve drainage following Montana road BMPs. • Avoid other disturbance to road, such as poor maintenance practices and grazing.	Rapid inventory to document improvements and condition.	Revised Washington Forest Practices Board methodology.

10.3.4.2 Agricultural BMPs

Grazing BMPs reduce grazing pressure along streambanks and riparian areas. Implementing BMPs may improve water quality, create narrower channels and cleaner substrates, and result in recovery of streambank and riparian vegetation. Effectiveness monitoring for grazing BMPs should be conducted over several years, making sure to start monitoring before BMPs are implemented. If possible, monitoring reaches should be established in pastures keeping the same management as well as in those that have changed. Where grazing management includes moving livestock according to riparian use level guidelines, it is important to monitor changes within the growing season as well as over several years. Monitoring recommendations to determine seasonal and long-term changes resulting from implementing grazing BMPs are outlined below in **Table 10-3**.

Table 10-3. Effectiveness Monitoring Recommendations for Grazing BMPs by Restoration Concern

Recovery Concern	Monitoring Recommendations	Methodology or Source
Seasonal impacts on riparian area and streambanks	• Seasonal monitoring during grazing season using riparian grazing use indicators. • Streambank alteration. • Riparian browse. • Riparian stubble height at bank and “key area”.	BDNF/BLM riparian standards (Bengeyfield and Svoboda, 1998)
Long-term riparian area recovery	• Photo points. • PFC/NRCS Riparian Assessment (every 5-10 yrs). • Vegetation Survey (transects perpendicular to stream and spanning immediate floodplain) every 5-10 years. • Strip transects- Daubenmire 20cm x 50cm grid or point line transects • Greenline.	Harrelson et al., 1994; Bauer and Burton, 1993; NRCS, 2001 Stream Assessment Protocols
Streambank stability	• Greenline including bare ground, bank stability, woody species regeneration (every 3-5 years)	Modified from Winward, 2000
Channel stability	• Cross-sectional area, with % fines/ embeddedness. • Channel cross-section survey. • Wolman pebble count. • Grid or McNeil core sample. • Bank Erosion Hazard Index.	Rosgen, 1996; Harrelson et al., 1994

Table 10-3. Effectiveness Monitoring Recommendations for Grazing BMPs by Restoration Concern

Recovery Concern	Monitoring Recommendations	Methodology or Source
Aquatic habitat condition	• Aquatic macroinvertebrate sampling. • Pool quality. • R1/R4 aquatic habitat survey. • Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments.	DEQ biomonitoring protocols; Hankin and Reeves, 1988; USFS 1997 R1R4 protocols DEQ Longitudinal Assessment Protocols (2009)
General stream corridor condition	• EMAP/Riparian Assessment (every 5-10 yrs).	NRCS 2001 Stream Assessment Protocols; U.S. EPA 2003.

10.3.4.3 Reclamation in Areas Affected by Historic Mining

Abandoned Mine Sites

Each reclamation site will have site-specific needs but general recommendations for abandoned mine site remediation effectiveness monitoring are outlined in **Table 10-4**.

Table 10-4. Effectiveness monitoring recommendations for abandoned mine reclamation sites.

Parameter	Monitoring Recommendations
Water quality	Sample for heavy metals, pH, flow and TSS in water column at high and low flow above and below mine site. Collect sediment samples at low flow. Monitoring should be initiated prior to remediation efforts and continue for at least 10 years after site restoration. If possible, monitoring should include biomonitoring (i.e. periphyton and macroinvertebrates) at low flow every 3 years.
Vegetation re-establishment	Greenline survey every 3 years, including bank stability, shrub regeneration, and bare ground. Vegetation transects across floodplain for vegetation community structure and regeneration.

Within Superfund Site Boundaries and Areas Affected By Smelter Fallout

Superfund-related effectiveness monitoring specifics are typically driven by the project goals and ARARs and are not discussed within this document. In general, because metals sources in areas where Superfund projects have been or will be implemented are very dispersed, monitoring of both surface and ground water will be necessary to determine the effectiveness of remedies and if additional reclamation work may need to occur in order to meet water quality standards.

Grant-funded projects in the Upper Clark Fork TPA will likely address many of the same issues and sources as the Superfund-related projects and should include effectiveness monitoring. Monitoring needs will vary depending on the project but should include surface water quality sampling and may include ground water sampling. In watersheds that are largely affected by elevated soils metals concentrations as a result of smelter fallout, monitoring during high flow and storm events, when soils are mostly likely to erode, is recommended. These watersheds include Lost, Modesty, Mill, Mill-Willow, Warm Springs, and Willow. In areas where the composition and vigor of the vegetative community was affected by atmospheric deposition, trends in vegetation should also be evaluated after BMP implementation.

10.3.5 Watershed Wide Analyses

The BMPs listed above are only a sample of the potential management practices that could be used in the Upper Clark Fork TPA to improve water quality and habitat. Recommendations for monitoring in the Upper Clark Fork should not be confined to only those streams addressed within this document. The water quality targets presented herein are applicable to all streams in the watershed, and the absence of a stream from the State's 303(d) List does not necessarily imply a stream Fully Supporting all beneficial uses. Furthermore, as conditions change over time and land management evolves, the consistent application of data collection methods and information collected throughout the watershed will best allow resource professionals to identify problems as they occur, and to track improvements over time. The recommendations and TMDLs developed in this document also relate to, and will ultimately help achieve the eventual TMDLs to be developed for the Clark Fork River, which is listed on the 303(d) List for metals, nutrients, and sediment.

SECTION 11.0
PUBLIC INVOLVEMENT & COMMENTS

Public and stakeholder involvement is a component of TMDL planning efforts. Stakeholders, including the Deer Lodge Conservation District, Watershed Restoration Coalition of the Upper Clark Fork (WRC), Clark Fork Coalition, Montana Natural Resource Damage Program, Montana Department of Natural Resources and Conservation, Montana Department of Fish, Wildlife & Parks, USDA – Natural Resource Conservation Service, USFS Beaverhead-Deerlodge National Forest, US Environmental Protection Agency, as well as local land owners and watershed residents were kept abreast of the TMDL process through periodic meetings of the Watershed Restoration Coalition and Deer Lodge Conservation District Board. In addition, Technical Advisory Group meetings, and other outreach and education efforts conducted by the WRC provided opportunities to review and comment on technical documents. Stakeholder review drafts were provided to several agency representatives, landowners, conservation district and government representatives, and representatives from conservation and watershed groups. Stakeholder comments, both verbal and written, were accepted and are addressed within the document.

An additional opportunity for public involvement is the public comment period. This public review period was initiated on November 27th, 2009 and extended to December 18th, 2009. At a public meeting on December 15th in Deer Lodge, MT, DEQ provided an overview of the Upper Clark Fork River Tributary Total Maximum Daily Loads, made copies of the document available to the public, and solicited public input and comment on the plan. This section includes DEQ's response to all official public comments received during the public comment period. This final document was updated, based on public input and comment.

11.1 Responses To Public Comments

The formal public comment period for the Upper Clark Fork River Tributaries Sediment, Metals, and Temperature TMDLs and Framework for Water Quality Restoration (TMDL) extended from November 27th to December 19th, 2009. Three individual comments letters were submitted to DEQ during the public comment period. Excerpts from comment letters are provided below and arranged by the individual or entity whom submitted. Responses prepared by DEQ follow each of the individual comments. Original comment letters are held on file at the DEQ and may be viewed upon request.

Will McDowell, Christine Brick - Clark Fork Coalition

Comment #1
The document does a thorough job of addressing the metals contamination issues in upper Clark Fork tributaries. This work will be very useful in guiding restoration priorities for metals-contaminated streams.

Response to #1
Thank you, your comment is appreciated.

Comment #2
The treatment of sediment and temperature issues does not appear to be complete, particularly due to an incomplete listing of the impaired streams. It is unclear how the review of the impaired streams was conducted. At one level it appears that the 2002 303(d) list was used, and that this list drove the process. However, in **Section 5**, regarding sediment impairments, a number of stream segments were added to the list of sediment-impaired streams. If adding sediment-impaired streams to the list was a possibility, why was there no more thorough attempt to identify sediment-impaired streams in the watershed through field assessments or complete review of literature?

Response to #2
TMDLs are required for pollutant-water body segment combinations on the 303(d) List. The streams addressed for sediment TMDL work included those streams from the most recent 303(d) List. Additionally, the DEQ also assessed streams with non-pollutant causes of impairment generally identified as habitat alterations. This was convenient since DEQ's TMDL field assessment process can apply to both sediment and most habitat alteration impairment conditions. Given the considerations of TMDL workload throughout Montana, the DEQ determined that there had to be limitations to the overall work scope for sediment TMDL work, with focus eventually on those streams identified as impaired by either sediment or habitat alteration causes at the time that TMDL work was initiated. If the TMDL assessment results for streams with habitat alteration causes of impairment suggested that writing a sediment TMDL was appropriate and would help facilitate restoration activities, then a sediment TMDL was written. If the results were inconclusive, then a sediment TMDL was not written.

We understand that there are usually additional impairment causes not addressed during TMDL development in any watershed. Therefore, there will be additional phases of TMDL development in the future that will potentially incorporate new impairment determinations for waters not previously assessed.

Comment #3
Several streams with major sediment impairments were surveyed by the Watershed Restoration Coalition in 2002/2003/2004/2005, and the sediment issues were clearly identified in detailed reports by Kirk Environmental ("East Valley Baseline Study" and "Browns Gulch Watershed Assessment"). These streams include: Orofino Gulch, Sand Gulch, Dry Cottonwood Creek, Perkins Gulch, and Browns Gulch. All of these streams have broad similarity in geology, and soils which are very vulnerable to erosion when disturbed. Roads and overgrazing are major issues here, and sediments are a major impairment to aquatic life and cold-water fish in these watersheds. For example, in **Section 5.3** of this TMDL, the East Valley Baseline report by Kirk Environmental, which includes data on sediment, on riparian assessments, and on roads, was published in 2004 but was not even cited.

Response to #3
As mentioned in the Response to Comment #2, we acknowledge there are streams in the Upper Clark Fork watershed that were not addressed within this document, however as the focus of those streams addressed was based on streams either on the 303 (d) list for a pollutant or

currently identified as impaired for habitat alterations, many of the east valley streams were not included. In addition, we are aware that there are good and thorough informational resources which help document the conditions on these streams and will be important to use for future assessment and beneficial use determinations, and the Kirk Environmental report you mention is certainly one of them.

Section 5.3 is included to acknowledge that information from many sources is available and has been used in the development of the TMDLs within this document. Two main sources of information were widely used for the analysis of sediment and habitat conditions, and as such they are highlighted. The Kirk Environmental report was cited in the analysis of Peterson Creek (**Section 5.4.5.5**, **Section 5.4.6.3**, **Section 6**), however because it dealt with a single stream in the context of this document, it was not considered one of the "main information sources used to assess sediment and habitat conditions in the Upper Clark Fork", and therefore not singled out for description. The Kirk Environmental report will serve as a source of information when formal DEQ assessment occurs on the east valley streams.

Comment #4
The UCF Tributary TMDL should be amended to acknowledge the severe sediment impairments in these additional streams in the project area.

Response to #4
Section 8 – Other Problems/Concerns, does acknowledge that water quality issues are not limited to those streams where TMDLs are developed and highlights that "the issues associated with these streams are still important to consider when attempting to improve water quality conditions in individual streams, and the Clark Fork watershed as a whole". Examples have been added to that discussion to strengthen this acknowledgement.

Comment #5
The temperature TMDL for Peterson Creek appears to be a thorough analysis of that issue for that stream. However, temperature issues are documented in several other UCF tributaries, in fact, this is a widespread issue. Again, the listing process was incomplete, and a number of temperature-impaired tributaries are not addressed. For example, data from the WRC-funded "Browns Gulch Watershed Assessment" (2006) notes that temperatures in lower Browns Gulch exceeded 70 degrees F for over a month, and some daily highs approached 80 degrees F. It is unclear why this and other data on stream temperature collected by Montana Fish Wildlife and Parks or others were not used.

Response to Comment #5
As described in the Response to Comment #2, streams that were addressed for temperature were driven by the listing history of the streams, and the resources available at the time of TMDL development. Because Peterson Creek is the only temperature impaired stream listed in the Upper Clark Fork TPA on the most recent 303 (d) list, and because modeling is often used which requires substantial data collection to determine standards exceedance and the allocations, no other streams were included for temperature TMDL development. Data sources such as the Browns Gulch Watershed Assessment can be used in the assessment and beneficial use determinations in the future. Note that the temperature standard, as discussed in **Sections 3** and

6, requires a variation from naturally occurring conditions. Therefore, temperature data alone is not adequate for making an impairment determination without a defensible link to controllable human causes leading to elevated temperatures.

Comment #6
In the upcoming nutrient TMDL analysis for the Upper Clark Fork, we would request that the selection of impaired tributaries use all known sources of data, and include a more complete list of tributaries which are actually impaired (many of the sediment-impaired streams mention in #5 above are also nutrient-impaired).

Response to Comment #6
DEQ attempts to identify and use all available data and informational resources in the development of TMDLs. As the future nutrient TMDL development will also include the Clark Fork River, and therefore all nutrient sources to the river, all relevant information from contributing tributaries will be reviewed, and TMDLs may be developed for currently non-listed streams as well, if warranted, taking into consideration available DEQ resources.

Comment #7
I think it would be helpful to include a discussion in the document of how the State TMDL program will coordinate restoration efforts with State DEQ, NRDP and Federal cleanup and restoration efforts through the upper watershed.

Response to Comment #7
Although DEQ is available to provide guidance for stakeholders regarding development of a WRP and TMDL implementation, coordinating TMDL implementation is outside of the scope of the TMDL program. However, agencies (including DEQ) are collaborating and coordinating restoration efforts throughout the watershed. A paragraph that discusses restoration coordination has been added to the end of **Section 9**.

Comment #8
Suggestions for Improvement of the Document:
The numeric identification of sampling points in tables throughout the document (e.g. sampling point P13) is confusing and difficult to use, even with constant reference to the maps. I would suggest using the "river mile" of each sampling point in each table, in order to make the information easier to understand and to use. The MFISH data base uses this system, which makes fisheries or water quality data much easier to understand.

Response to Comment #8
DEQ will consider including the river mile information in the discussion of monitoring locations/data points in the future and appreciates this suggestion to improve the use and sharing of information.

*Additional editorial comments were submitted by the Clark Fork Coalition and corrections were made within the document.

Steve Flynn - Sun Mountain Lumber

Comment #9
This is in response to the Draft Upper Clark Fork River Tributaries Sediment, Metal and Temperature TMDLs and Framework for Water Quality Restoration. I would like to thank you and your staff for putting together a very readable and understandable document. It explains the elements of a TMDL very clearly and how these elements are developed. It is a document I know I will use as a reference in the future.

Response to #9
Thank you, your comment is appreciated.

Comment #10
The data for metals and temperature in the analyzed streams is empirical and can be quantified with precise measurements. The source or cause of metal concentrations and temperature levels can also be readily identified. The same is not true of upland and road sediment. My concern is that future forestry or agricultural management activities in upland areas may be reduced or prevented as a result of this necessarily subjective analysis of sediment from upland non point sources. I would like to see a clarification in the document that with the proper application of Best Management Practices for Forestry, along with adherence to the Streamside Management Law, that increased sedimentation from agricultural or forestry activities would be negligible.

Response to Comment #10
Sediment loads can be quantified and sources and causes can be identified as well, however, DEQ does concede that attaining a high level of accuracy when quantifying sediment loads is often very difficult, and analysis relies heavily on assumption and extrapolation, especially at the watershed scale.

As discussed in **Section 3.1**, TMDLs are developed for each water body-pollutant combination identified on the states list of impaired or threatened waters and are often presented within the context of a water quality restoration or protection plan. State Law (Administrative Rules of Montana 75-5-703 (8)) also directs DEQ to "support a voluntary program of reasonable land, soil, and water conservation practices to achieve compliance with water quality standards for nonpoint source activities for water bodies that are subject to a TMDL…" This wording of "reasonable land, soil, and water conservation practices" does allow for timber harvest and other land management activities to occur and, in most cases, implies the resultant load is acceptable when these reasonable practices are in place. While the DEQ supports a voluntary program of practices, the DEQ also supports compliance with all required water quality protection rules and regulations such as SMZ law. This document acknowledges and incorporates this application of reasonable land, soil, and water conservation practices in the development of all TMDLs and allocations. Furthermore, **Section 9** discusses adherence to SMZ laws and best management practices for forestry, and other land management activities as a means to achieve the TMDL, and therefore does not explicitly affect or limit future land use activities. However, in all cases, sound and responsible land use management and related activities should be applied, and consideration of the ability to sustain the natural resources that may be affected by these activities should be included in the actions that are taken.

It is important to note, however, that there is no equivalent SMZ law applicable to agricultural activities, and therefore meeting the TMDL allocation for agriculture relies mostly on voluntary measures as identified in **Section 9**.

Dr. Vicki Watson – University of Montana

Comment #11
It contains a lot of information, and the parts I read are clearly written. But at the end, I felt like nothing is going to happen. The main thing it says about implementation (p 237) is:
'DEQ does not implement TMDL pollutant reduction projects for nonpoint source activities… but can provide ... assistance for stake holders interested in improving their water quality.'

'Because most nonpoint source reductions rely on voluntary measures… (paraphrasing) local stakeholders must work together to achieve water quality restoration…'

It seems to me this just reassures those contributing to water quality problems that they can continue business as usual because the state plans to do nothing about the water quality impairments.

The TMDL does mention that the Superfund work is about to start on the main stem and says that superfund cleanup may not fix all the problems and more work may be needed (p250).

But it should say that dovetailing water quality restoration (TMDL) work with the Superfund cleanup and NRDP restoration work is our most cost effective and efficient strategy for achieving the goals of all 3. And that those who do not cooperate with this effort now may find themselves paying for more of the necessary water quality improvement actions on their own later.

Response to Comment #11
Dovetailing TMDL with Superfund and other agency work in the basin is truly an important goal for all of those interested in improving water quality and habitat in the Upper Clark Fork TPA, and to the extent possible this should be a main priority to achieve a "cost effective and efficient strategy". It should be recognized, however, that while the stakeholders should work in partnership as much as possible, they all also have their own specific priorities and goals to meet that may not always overlap. **Sections 9** and **10** provide some guidance on implementation and monitoring, as well as integration with other Upper Clark Fork watershed efforts, and the results of the various source assessments presented in the document and appendices should assist in prioritizing future work. The implementation of the sediment and temperature TMDLs in this watershed however are, for the most part, a voluntary process and as such relies heavily on collaboration, education, and cooperation. This is primarily due to the limited regulatory requirements to address many of the primary causes of sediment pollution. On the other hand, a significant portion of the metals TMDLs will be implemented via ongoing Superfund and other cleanup activities identified within the document.

Fortunately, the Upper Clark Fork has numerous interested and active stakeholders and agencies invested in this effort. Specifically, the Watershed Restoration Coalition (WRC) and Deer Lodge Conservation District are two major players who have an opportunity to bring together the information (from Superfund, NRDP, and future TMDLs) into a more concerted and effective plan for restoration. **Section 9** discusses the importance of a Watershed Restoration Plan (WRP), the goal of which is to compile information and needs into a more comprehensive and specific implementation plan for the watershed, and the WRC currently has been allocated funds through a 319 grant to complete this task. DEQ strongly encourages those people who have a vision for and interest in water quality in the Upper Clark Fork to become engaged in this process, and help ensure that improvements do occur and action is taken.

Comment #12
I realize that the TMDLs for the Clark Fork, Silver Bow Creek, Little Blackfoot and TMDLs for nutrients for the whole area are still to come. But with Superfund work about to commence on the mainstem, and with the NRDP program proceeding to nail down their priorities for the basin, any TMDL that pertains to the upper Clark Fork would do a valuable service by giving a list of fairly specific priority actions that would likely produce the greatest water quality & fisheries benefits.

Response to Comment #12
This document does contain some general, and some specific goals for implementation and monitoring in **Section 9** and **10**, however specific detail on individual projects that may be implemented is often not a part of a TMDL document. Rather the TMDL document serves as the framework for water quality restoration, and a Watershed Restoration Plan, as mentioned in the response to Comment #11, can take the TMDL to the next step by identifying and prioritizing projects to help ensure the “biggest bang for the buck” when it comes to water quality restoration.

Comment #13
Concerning the upcoming TMDLs for the Clark Fork, Silver Bow Creek, Little Blackfoot -- how will these be integrated with or related to the Superfund & NRDP efforts? Will it just be up to the WRC to propose projects or will DEQ provide some project priorities in those TMDLs?

Response to #13
Inter-agency communication and information sharing has occurred, and continues to occur in the Upper Clark Fork watershed which will help to integrate the efforts of Superfund, NRDP, and DEQ. Additionally, the WRP as mentioned in the responses to comments #7, #11, and #12, is intended to incorporate a broader view of activities and priorities in the basin, and focus them into a more concerted and comprehensive management plan. The WRP is intended to be a “living document”, in that it should be maintained and adapted as new information becomes available and priorities change.

SECTION 12.0
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